DUNDEE CITY COUNCIL

LOCAL AIR QUALITY MANAGEMENT

PROGRESS REPORT 2007

Ref: Air Quality 2007 Progress Report February 2008

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REFERENCES

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GLOSSARY OF ACRONYMS AND DEFINITIONS

AADT	Annual Average Daily Traffic Flow
ADMS	An atmospheric dispersion model
AEAEE	AEA Energy & Environment
annualise	the means of estimating an annual mean from a shorter study period mean by comparison with full datasets from background AURN sites
AQ Archive	UK Air Quality Archive
AQMA	Air Quality Management Area
AQS	Air Quality Strategy
AURN	Automatic Urban and Rural Network (Defra funded air quality monitoring network)
CHP	Combined Heat and Power
CO	Carbon Monoxide
Defra	Department for Environment, Food and Rural Affairs
DERL	Dundee Energy Recycling Ltd
DMRB	Design Manual for Roads and Bridges
EC	European Community
EHTS	Environmental Health and Trading Standards Department
EPA	The Environmental Protection Act 1990
EPAQS	Expert Panel on Air Quality Standards
EU	European Union
GF	Ground floor
GIS	Geographical Information System
HDV	Heavy goods vehicles and buses
HGV	Heavy Goods Vehicle
IPC	Integrated Pollution Control
kerbside	0 to 1 metre from the kerb
LAQM.TG(03)	Local Air Quality Management: Technical Guidance (2003)
Limit Value	An EU definition for an air quality standard of a pollutant listed in the air quality directives
MW	Mega Watts
mg/kg	Milligrams per Kilogram
mg/m^3	Milligrams per cubic metre
NAEI	National Atmospheric Emission Inventory
NAQS	National Air Quality Standard
NO	Nitric Oxide
NO_2	Nitrogen Dioxide
NO_X	Oxides of nitrogen
ng/m^3	Nanograms per cubic metre
NRTF	National Road Traffic Forecast
OSIRIS	the brand name given by Turnkey Instruments Ltd. to their particle measuring nephalometer
P&T	Planning and Transportation
$PM_{2.5}$	Particulate Matter less than 2.5μm aerodynamic diameter
PM_{10}	Particulate Matter less than 10μm aerodynamic diameter
Pb	Lead
percentile	The percentage of results below a given value

ppb	Parts per billion
ppm	Parts per million
receptor	In this study, the relevant location where air quality is assessed or predicted (for example, houses, hospitals and schools)
roadside	1 to 5 m from the kerb
SCA	Smoke Control Area
SEPA	Scottish Environment Protection Agency
SO_2	Sulphur Dioxide
Street Canyon	A relatively narrow street with buildings on both sides, where the height of the buildings is generally greater than the width of the road
TEA	Triethanolamine
TEOM	Tapered Element Oscillating Microbalance
UKAS	United Kingdom Accreditation Service
$\mu g/m^3$	Micrograms per cubic metre
VOC	Volatile Organic Compound
vpd	Vehicles per day
WASP	Workplace Analysis Scheme for Proficiency

EXECUTIVE SUMMARY

This document is the 2007 Progress Report on air quality for the Dundee City Council area. The report focuses on each of the pollutants listed in Air Quality Regulations that were monitored within the council area during 2006, these were; nitrogen dioxide, sulphur dioxide, and fine particulate matter (PM_{10}).

Local authorities are required to assess the levels of seven pollutants that are known to have adverse health effects, on a three yearly basis. The review and assessments of air quality are carried out to determine if the pollutant levels that the public are exposed to can be achieved by the set target dates, or if additional local measures will need to be taken to address identified polluted areas.

Previous assessments of air quality established that there was no problem with the levels of some of the seven pollutants namely; benzene, carbon monoxide, 1,3-butadiene, sulphur dioxide and lead. However, exceedences of the acceptable standard for nitrogen dioxide have been identified and an Air Quality Management Area was declared for this pollutant in July 2006.

The results of previous assessments were inconclusive for PM_{10} and it was concluded that additional monitoring and modelling would be required to determine whether an AQMA for PM_{10} would be required.

This Progress Report concentrates primarily on new monitoring data and new local developments that have the potential to affect local air quality. It also provides information to assist in other policy areas, such as transport and land use planning within the council. Each pollutant has been assessed in conjunction with the relevant guidance and the conclusions reached are:

Nitrogen dioxide – analysis of the 2006 data for nitrogen dioxide has reconfirmed the need for the AQMA and development of an Action Plan. Two new areas of potential exceedence of the annual mean have been identified at the Kingsway/Forfar Road and ArbroathRoad/Albert Street Junctions.

Small Particulates (PM_{10}) – Dundee City Council's PM_{10} monitoring intercomparison study established a local gravimetric correction factor of 1.05. Despite being lower than the national gravimetric correction factor, when the local factor is applied to monitored data exceedences of the 2010 PM_{10} annual mean objective are still predicted for the following locations:

- Victoria Road / Hilltown Junction
- Seagate
- Logie Street
- Lochee Road

Union Street is also very close to exceeding the annual mean objective in 2010, and remains an area of concern due to increasing PM_{10} concentrations at this city centre location.

More than seven exceedences of the 24-hour mean standard were also recorded at the same locations during 2006. The PM_{10} concentrations were measured using OSIRIS monitors which are not recommended for detailed assessments; hence additional gravimetric equivalent monitoring and / or modelling will be required at these 5 locations.

In addition it has been predicted that the extra traffic and necessary junction works associated with a new superstore will lead to an exceedence of the PM_{10} annual mean objective (2010) at existing receptors close to the Kingsway/Forfar Road junction. A six month monitoring study will commence in the area once the junction works are completed to check the accuracy of the modelled predictions.

The 2006 PM_{10} results indicate that a detailed assessment of PM_{10} will be required.

Sulphur Dioxide -The monitoring results for 2006 indicate that all the NAQS objectives were met at monitoring locations in Dundee. Exceedences of the 15min objective occurred at the Broughty Ferry Road site, these were well below the 35 exceedences allowed and were thought to be caused by certain shipping movements and activities. A detailed assessment is not currently required for this pollutant.

SECTION 1 INTRODUCTION

This document is the 2007 Progress Report on air quality for Dundee City Council. It reports new monitoring data collected in 2006 and highlights any new local developments that have the potential to affect local air quality that have not been discussed in previous reports. Progress Reports form part of the local air quality management (LAQM) regime which was introduced by the Environmental Act 1995 and subsequent regulations.

The Air Quality Strategy for England, Scotland, Wales and Northern Ireland[1], established the framework for air quality improvements. Despite measures agreed nationally and internationally, it was recognised that areas of poor air quality would remain, and that these would be best dealt with by using local measures implemented through the Local Air Quality Management (LAQM) regime. As part of this regime, local authorities are charged with the responsibility of assessing the presence and amount of seven key pollutants (1,3-butadiene, benzene, carbon monoxide, lead, nitrogen dioxide, fine particulate matter and sulphur dioxide) which are known to have adverse health effects.

A summary of the statutory standards[2] and objectives for the pollutants currently being monitored in Dundee is shown in **Table 1a**. The air quality standards are based purely on medical evidence of the effects of particular pollutants on health. The objectives provide a measure for each of the pollutants against which future progress can be judged.

[1] DETR (2000) The Air Quality Strategy for England, Scotland, Wales and Northern Ireland – Working together for Clean Air, The Stationery Office
[2] DETR (2000) The Air Quality Regulations 2000 (Scotland), The Stationery Office, Scottish Executive (2002) Air Quality (Scotland) Amendment Regulations 2002

Table 1a - Summary of Air Quality Objectives for pollutants currently being monitored in Dundee

Pollutant	Air Quality Objective		Date to be achieved by
	Concentration	Measured as	
Nitrogen dioxide (NO_2) [a]	200 μg/m^3 not to be exceeded more than 18 times a year	1 hour mean	31.12.2005 [b]
	40 μg/m^3	annual mean	31.12.2005 [b]
Particles (PM_{10}) (gravimetric)[c] (All authorities)	50 μg/m^3 not to be exceeded more than 35 times a year	24 hour mean	31.12.2004
	40 μg/m^3	annual mean	31.12.2004
Particles (PM_{10}) (gravimetric)[c] (Scotland)	50 μg/m^3 not to be exceeded more than 7 times a year	24 hour mean	31.12.2010
	18 μg/m^3	annual mean	31.12.2010
Sulphur dioxide (SO_2) (All authorities)	350 μg/m^3 not to be exceeded more than 24 times a year 125 μg/m^3 not to be exceeded more than 3 times a year 266 μg/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

a The UK objectives for nitrogen dioxide are termed provisional within the Regulations, as they bring forward the requirement to meet the EU target date for health benefits.
b The EU Air Quality Standards (99/30) target date is 01/01/2010.
c Measured using the European gravimetric transfer sampler or equivalent.

1.1 SUMMARY OF THE PREVIOUS ROUNDS OF REVIEW AND ASSESSMENT OF AIR QUALITY IN DUNDEE

The review and assessments of air quality are carried out in a phased approach following the framework described in the statutory technical guidance.[3] The primary objectives of undertaking a review of air quality are to identify any areas that are unlikely to meet national air quality objectives and ensure that air quality is considered in local authority decision-making processes.

This report presents the findings of the latest review of Dundee City Council's air pollution monitoring. Previous review and assessments have been reported as follows:

- Stage 1 (1998) and Stage 2 (2000)
- Updating and Screening Assessment (2003)
- Detailed Assessment (2005)
- Progress Report (2005)
- Updating and Screening Assessment (2006)

[3] DEFRA & Scottish Executive 2003, Part IV of the Environment Act 1995 Local Air Quality Management Technical Guidance LAQM.TG(03), DEFRA Publications

The previous assessments of the air quality in Dundee City concluded that there were likely exceedences of the annual mean objective for NO_2 as a result of traffic sources in Dundee, in the following areas:

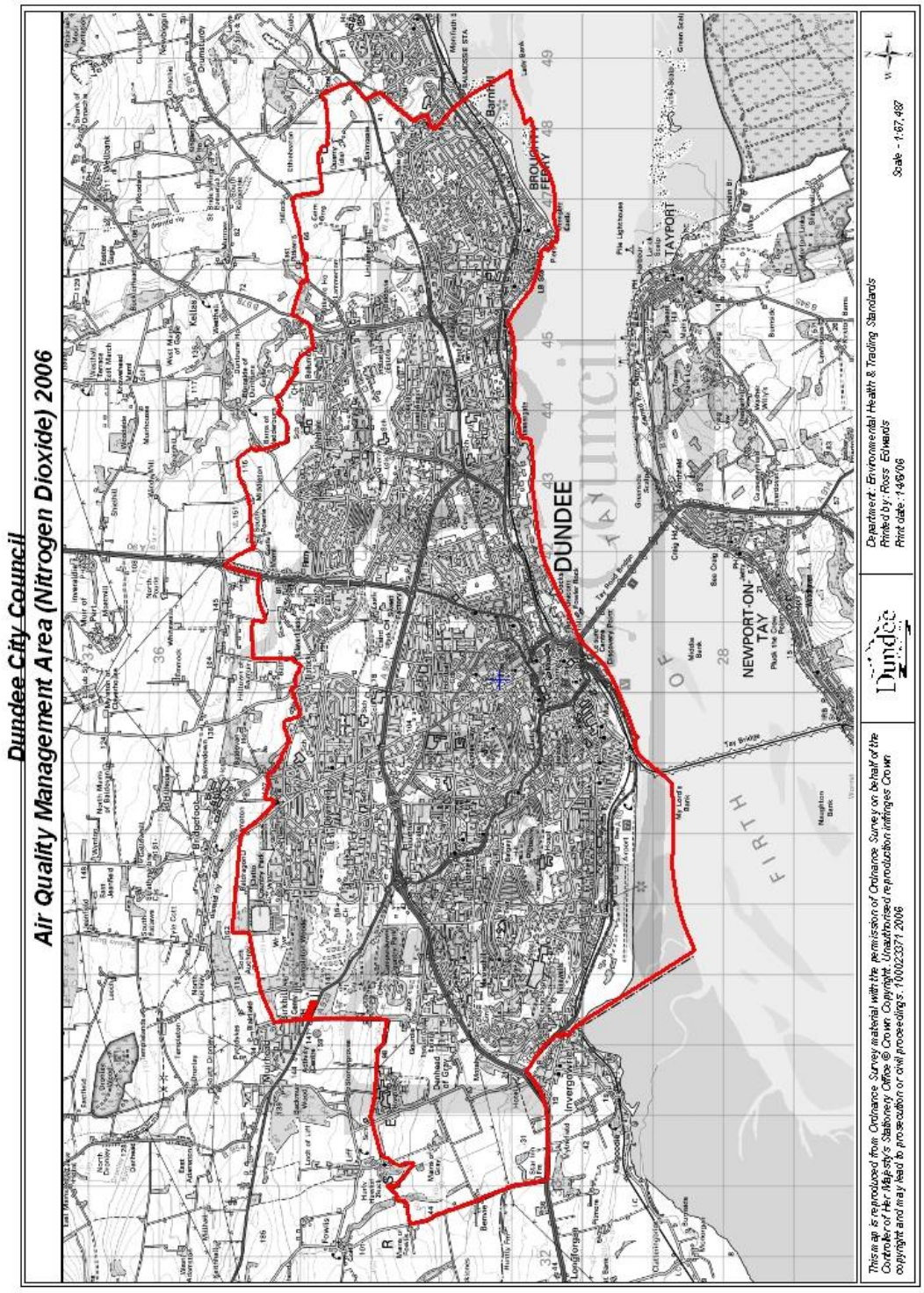
- Seagate
- Nethergate / Marketgait Junction
- Dock Street
- Commercial Street
- Victoria Road / Hilltown Junction
- Meadowside
- Lochee Road / Rankine Street Junction
- Lochee Road / Dudhope Junction
- Logie Street / Loons Road Junction

Following the detailed modelling of the NO_2 and PM_{10} concentrations in Dundee, it was proposed that the whole of Dundee be declared as an Air Quality Management Area (AQMA) for NO_2 in July 2006. ***Figure 1.1(1)*** shows the extent of the AQMA for NO_2.

Declaration of the AQMA is not the end of the process. The council has to undertake "Further Assessment" of the aforementioned areas in order to quantify how the various NO_2 sources contribute to the high pollutant levels identified and develop an "Action Plan" to try and improve the situation.

The results of the Detailed Assessment were inconclusive for PM_{10} as there was insufficient confidence in the verification of the modelled results for 2010. It was concluded that additional monitoring and modelling would be required to determine whether an AQMA for PM_{10} would be required.

Figure 1.1(1) - Dundee City Council Air Quality Management Area (Nitrogen Dioxide) 2006



SEPA, and the Scottish Executive accepted the conclusions of the Detailed Assessment and funded the expansion of the PM_{10} monitoring network. This included OSIRIS particulate monitoring in potential areas of exceedence, a new background site, a local gravimetric factor intercomparison study and speciation of particles.

The outcome of the Updating and Screening Assessment showed that the only monitored PM_{10} concentrations predicted to exceed the annual mean objective (2010) were in Union Street (see 2006 report[4]). However, this result was adversely influenced by major construction projects in the vicinity and may not have been truly representative of ambient concentrations present at this location.

No exceedence of the PM_{10} objectives were predicted for any roads or junctions studied. However, an air quality assessment received by the Council indicated a potential exceedence of the annual mean objective (2010) close to the Kingsway/Forfar Road junction. This indicated that a detailed assessment of this junction may be required, however there was uncertainty regarding the assumed traffic speeds and the background PM_{10} concentrations used in the developer's assessment.

Interim findings of the local gravimetric correction factor study suggested that the monitored and modelled PM_{10} exceedences may have been significantly over-estimated. Monitoring at the new background site (Mains Loan) and the intercomparison study site was to be continued in order to clarify whether this was the case.

Accordingly, it seemed prudent to delay the decision to undertake further detailed assessment of PM_{10} until the results of this additional monitoring was available. The results obtained are presented in this report.

[4] Updating and Screening Assessment 2006 is available online:
http://www.dundeecity.gov.uk/dundeecity/uploaded_publications/publication_609.pdf
http://www.dundeecity.gov.uk/dundeecity/uploaded_publications/publication_610.pdf

SECTION 2 PURPOSE OF THE PROGRESS REPORT

Following consultation on the LAQM process, the Government concluded that it was too 'stop-start' and that gaps of several years might occur between air quality reviews. Updating and Screening Assessments are now required at intervals of three years whilst Progress Reports maintain continuity and are to be produced in the intervening years.

Progress Reports are designed to ensure continuity in the LAQM process and are intended to assist local authorities by:

- providing a means for communicating air quality information to members and the public;
- maximising the usefulness and interpretation of the monitoring effort being carried out;
- maximising the value of the investment in monitoring equipment;
- helping local authorities respond to requests for up-to-date information on air quality;
- providing information to assist in other policy areas such as transport, land use planning and climate change;
- providing a source of baseline data for strategic environmental assessments;
- providing a ready source of information on air quality for developers carrying out environmental assessments for new schemes;
- demonstrating progress with implementation of air quality Action Plans and/or air quality strategies; and
- providing a timely indication of the need for further measures to improve air quality, rather than delaying until the next full round of review and assessment.

SECTION 3 NEW MONITORING RESULTS

3.1 MONITORING METHODS

3.1.1 Continuous Monitoring sites within Dundee

Dundee City Council had 10 locations at which air pollutants were monitored continuously during 2006. A summary of these locations and the pollutants monitored is shown in **Table 3.1a**. A map of these locations is shown in ***Figure3.1(1).***

Figure 3.1(1) - Location of Continuous Monitors in Dundee during 2006

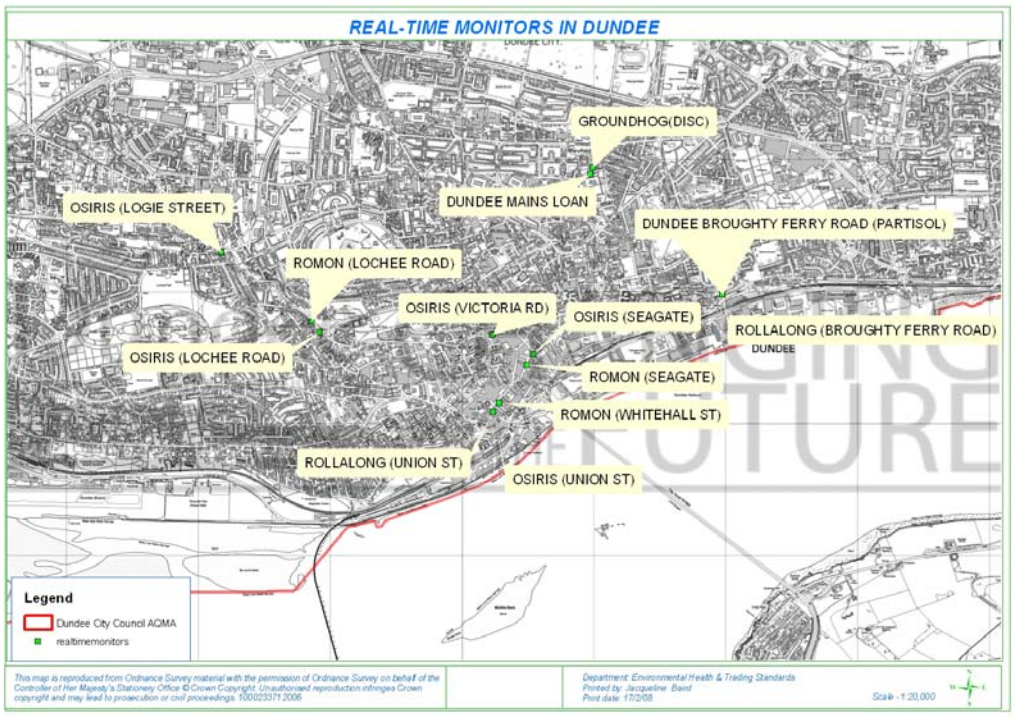


Table 3.1a - Summary of continuous monitoring locations

Location	Site Type	Pollutants Monitored	Timescale
Groundhog Mains Loan[$]	Periodic background	SO_2 / PM_{10} (TEOM) / NO_2	Periodic since 1999
Union Street Rollalong	Roadside (1.35m from the kerb)	PM_{10} (TEOM & OSIRIS)/ NO_2	Nov 2000 to present
Broughty Ferry Road. Rollalong* & Partisol	Downwind of Docks (approx. 350m from a petroleum refinery)	PM_{10}(TEOM) / SO_2	Jan 2002 to present
		PM_{10} (gravimetric)	Started June 2006
Seagate Romon	Kerbside	NO_x/NO_2	Jan 2004 to present
Lochee Road Romon	Kerbside	NO_x/NO_2	Jan 2004 to present
Whitehall Street Romon	Kerbside	NO_x/NO_2	July 2003 to present
Victoria Road (Osiris)	Kerbside	PM_{10}	April 2005 to present
Logie Street (Osiris)	Kerbside	PM_{10}	April 2005 to present
Lochee Road (Osiris)	Kerbside	PM_{10}	April 2005 to present
Seagate (Osiris)	Kerbside	PM_{10}	April 2005 to present
Mains Loan	Background	PM_{10} (TEOM)	Started April 2006

Notes:
$ - The Groundhog is a mobile air quality station, which is shared with Angus and Fife Councils, spending approximately 6 months with each local authority. The Groundhog was located in Dundee for six months during 2006.
* - although the monitor referred to as being located on Broughty Ferry Road, it is located at the corner of Dock Street and Broughty Ferry Road, some of the graphs used in the report refer to the monitor as Dock Street.

3.1.2 Data Validation and Ratification

The basic principles of data management for automatic air quality monitors are presented in the technical guidance LAQM.TG(03), and in the Automatic Urban and Rural Network (AURN) Local Site Operators Manual[5].

Dundee City Council secured funding from the Scottish Executive, to commission AEAEE[6] to assist with data management and ratification procedures in line with the advice given in the 2006 update to the LAQM.TG(03). Dundee joined the 'Calibration Club' run by AEAEE at the end of 2006 and AEAEE were able to ratify all the 2006 real-time monitor data presented in this report.

[5] http://www.aeat.co.uk/netcen/airqual/reports/lsoman/lsoman.html
[6] AEA Energy & Environment who manage seven of the eight National Air Quality Monitoring Networks

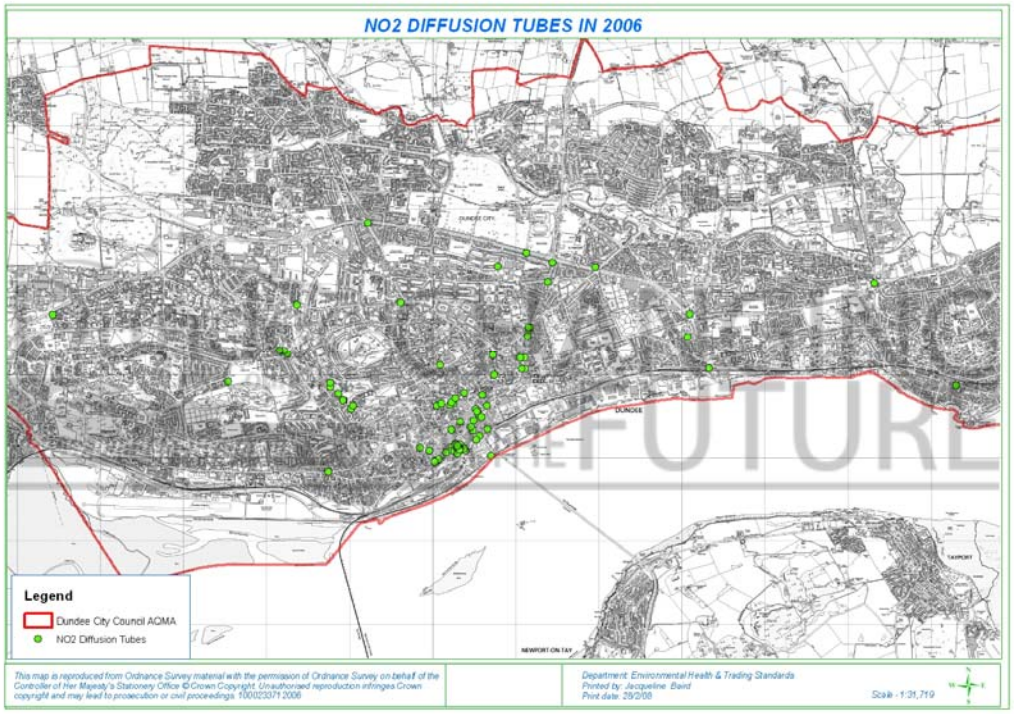
3.1.3 Explanation of the use of percentiles for reporting monitoring data

The short-term air quality objectives (e.g.15 minute, 1 hour, 24 hour) are framed in terms of the number of occasions in a calendar year on which the objective concentration should not be exceeded (see **Table 1a**). Wherever possible, authorities are encouraged to express the results of their monitoring and modelling in terms of the number of hours, days etc. above the objective level. This is the clearest basis for strict comparison with the objectives set out in the 2000 and 2002 Regulations. However, for a strict comparison on this basis, there must be a minimum of 90% data capture throughout a calendar year. In certain circumstances, where measured data capture is less than 90%, it is considered appropriate to express short-term concentrations as percentile values that approximate to the permitted number of exceedences.

3.1.4 Passive Diffusion Tube Monitoring Sites

Dundee City Council had 87 passive diffusion tubes monitoring nitrogen dioxide throughout the city, during 2006. These were located at 79 sites including, busy roads and junctions as well as urban background sites. A map of these locations is shown in ***Figure 3.1(2).***

Figure 3.1(2) - Nitrogen Dioxide Diffusion Tubes in 2006



3.1.5 Wind Speed and Direction in Dundee in 2006

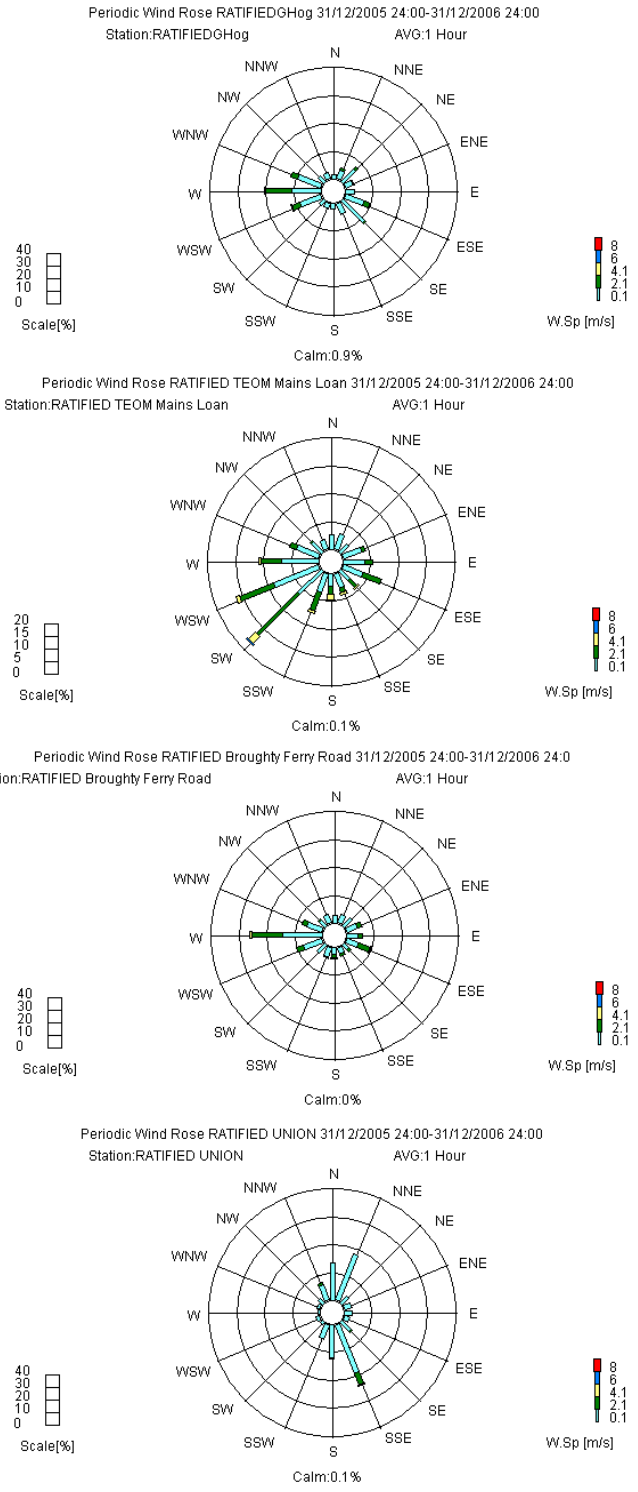
In previous reports the prevailing wind direction for Dundee has been described as south-westerly. This is indeed true for the whole of the British Isles. Wind speed increases with height above ground and most meteorological data is normalised and expressed as a speed at 10 metres above ground.

Four of the continuous analyses in Dundee are equipped with anemometers:

- Groundhog, Mains Loan - monitor was shielded to south and southwest by a building
- TEOM, Mains Loan - in an open location
- Rollalong, Broughty Ferry Road - in an open location
- Rollalong, Union Street - in a street canyon

Figure 3.2(3) shows the wind speed and direction monitoring at these locations in 2006. The wind measurements have not been normalised to 10m and therefore tend to be more representative of the local wind environment and its potential to disperse pollutants found in those locations. The wind roses highlight how topographical features such as hills, the built environment, e.g. the presence of buildings or street canyons, can influence local wind direction.

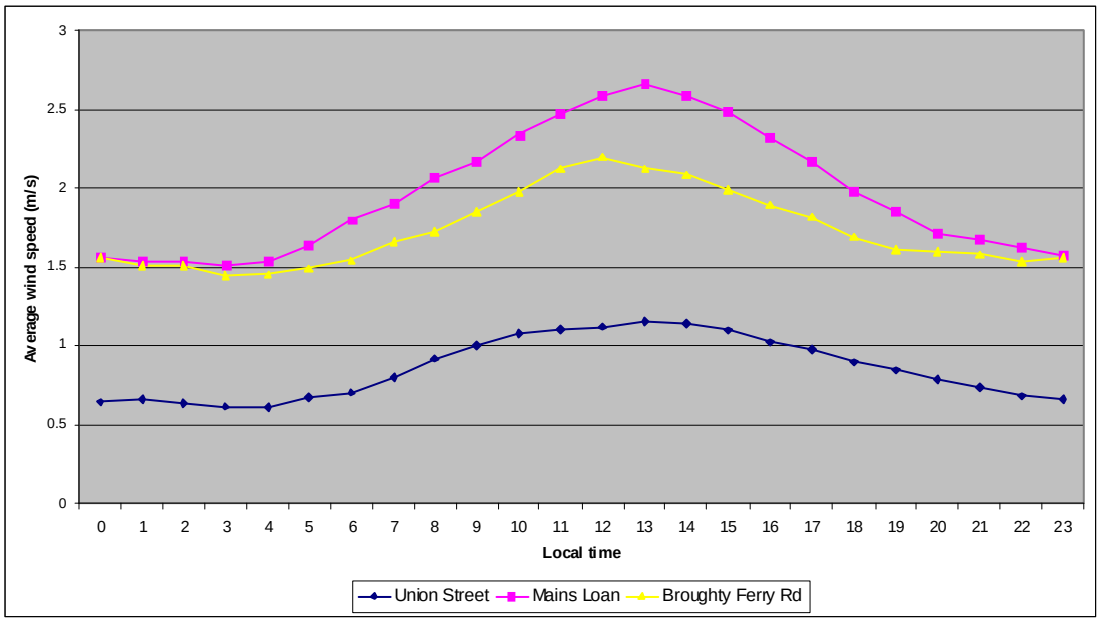
Figure 3.1(3) - Wind Roses showing wind speed and direction of four monitoring locations in Dundee for 2006



The effect of the built environment on wind speed is illustrated by the diurnal plots of average hourly wind speed for each hour of the day in 2006, recorded at two open locations and in one street canyon (see **Figure 3.1(4)**). Union Street is orientated approximately perpendicular to the prevailing winds and in consequence it can be seen that the average wind speeds are substantially lower than those recorded at open locations.

It is observed that, at all locations, wind speeds are lowest overnight. The implications of these phenomena mean that, in built up areas, pollutants emitted close to ground level (e.g. NO_2 or PM_{10} from vehicle exhausts) not only tend to build up throughout the working day but take longer to disperse, as average wind speeds decrease through the night.

Figure 3.1(4) - Comparison of average hourly wind speeds at two open locations (Mains Loan (background site) and Broughty Ferry Road), and a street-canyoned roadside location (Union Street) in 2006



3.2 NITROGEN DIOXIDE (NO_2)

OBJECTIVES :

40 micrograms per cubic metre or less, when expressed as an annual mean, to be achieved by 31st December 2005.

200 micrograms per cubic metre or less, when expressed as an hourly mean, not to be exceeded more than 18 times a year to be achieved by 31st December 2005.

3.2.1 Continuous Monitoring Results

3.2.1.1 Measurement Method

The determination of oxides of nitrogen is based on the chemiluminescent energy emitted when nitric oxide (NO) is reacted with ozone (O_3) in an evacuated chamber to form chemiluminescent nitrogen dioxide (NO_2). The chemiluminescent analyser is the reference method specified in the EU First Air Quality Daughter Directive, and is widely used for continuous monitoring of NO_2 concentrations in the UK.

3.2.1.2 Instrumentation

The type of instrument used at each location is the Monitor Labs 9841A.

3.2.1.3 Data Quality Requirements

The basic principles of data ratification for automatic air quality monitors are presented in the LAQM.TG(03) and in the AURN Local Site Operator's Manual[7]. Automatic monitoring data presented in this report has been ratified by AEAEE on behalf of Dundee City Council.

3.2.1.4 Summary of Annual Mean Nitrogen Dioxide Results

Automatic Monitoring results for the period 1 January to 31 December 2006 are shown in **Table 3.2a**, along with annual mean results for previous years, where available. Where there has been poor data capture (i.e. <75%) results have been annualised using comparable hourly data from the nearest AURN urban background sites at Aberdeen and Edinburgh St. Leonards.

The Groundhog is a mobile air monitoring station which is shared by Angus and Fife Councils, spending approximately six months with each local authority. In 2006 the Groundhog was located in an urban background site at Mains Loan for six months from 17th March to 17th September.

[7] http:/www.aeat.co.uk/netcen/airqual/reports/Isoman/isoman.html

Table 3.2a - Summary of Annual Mean NO_2 Results ($\mu g/m^3$) from Continuous Monitors

Location	2001 Annual Mean NO_2 (%data)	2002 Annual Mean NO_2 (%data)	2003 Annual Mean NO_2 (%data)	2004 Annual Mean NO_2 (%data)	2005 Annual Mean NO_2 (%data)	2006 Annual Mean NO_2 (%data)
Union Street Rollalong	48.5 (93.3)	42.0 (86.6)	40.6 (86.8)	41.2 (85.5)	36.6^ (94.6)	39.0' (59.9)
Whitehall Street Romon	n/a	n/a	n/a	39.3 (60.0*)	39.4" (93.8)	39.8 (85.1)
Seagate Romon	n/a	n/a	n/a	64.5 (85.0)	59.9" (92.2)	43.0' (60.7)
Lochee Road. Romon	n/a	n/a	n/a	79.6 (96.0)	67.7" (93.5)	49.0' (63.4)
Groundhog Mains Loan	n/a	n/a	n/a	16.0 (50.9)	n/a	12.1 (48.1)

*Monitoring at Whitehall Street Romon had to be suspended during 2004 as a consequence of works associated with the bus interchange development in this street
%data - percentage data capture
^ data scaled and ratified
" figures based on screened data
'ratified data annualised using comparable hourly data from AURN Background sites (Aberdeen and Edinburgh St.Leonards)

Previously, to enable comparison with the 2005 annual mean objective, annual means measured between 2001 and 2004 were predicted forward to 2005 using appropriate correction factors supplied in the Technical Guidance[89] **Table 3.2b** compares the predicted values with those recorded in 2005 and 2006. This comparison is helpful to illuminate trends in the data and determine whether national measures to reduce pollutant concentrations are actually taking effect.

[8] Department for Environment Food and Rural Affairs and Scottish Executive 2003, 'Part IV of the Environment Act 1995 Local Air Quality Management Technical Guidance LAQM'. TG(03), DEFRA Publications. Page 6-8

[9] Department for Environment Food and Rural Affairs and Scottish Executive 2003, 'Part IV of the Environment Act 1995 Local Air Quality Management Technical Guidance LAQM'. TG(03), DEFRA Publications. Page 6-29, Box 6.7

Table 3.2b - Summary of Annual Mean NO_2 (µg/m^3) Predicted to 2005 for comparison with the Annual Mean Objective (40 µg/m^3)

Location	2001 Annual Mean NO_2 Predicted to 2005	2002 Annual Mean NO_2 Predicted to 2005	2003 Annual Mean NO_2 Predicted to 2005	2004 Annual Mean NO_2 Predicted to 2005	2005 Measured Annual Mean NO_2	2006 Measured Annual Mean NO_2
Union Street Rollalong	43.3	38.7	38.5	40.2	36.6^	39.0'
Whitehall St. Romon	n/a	n/a	n/a	38.3*	39.4"	39.8
Seagate Romon	n/a	n/a	n/a	62.9	59.9"	43.0'
Lochee Road. Romon	n/a	n/a	n/a	77.6	67.7"	49.0'
Groundhog Mains Loan	n/a	n/a	n/a	15.7	n/a	12.1

*Monitoring at Whitehall Street Romon had to be suspended during 2004 as a consequence of works associated with the bus interchange development in this street
^ data scaled and ratified
" figures based on screened data
'ratified data annualised using comparable hourly data from AURN Background sites (Aberdeen and Edinburgh St.Leonards)

3.2.1.5 Summary of Hourly Average Concentrations in 2006

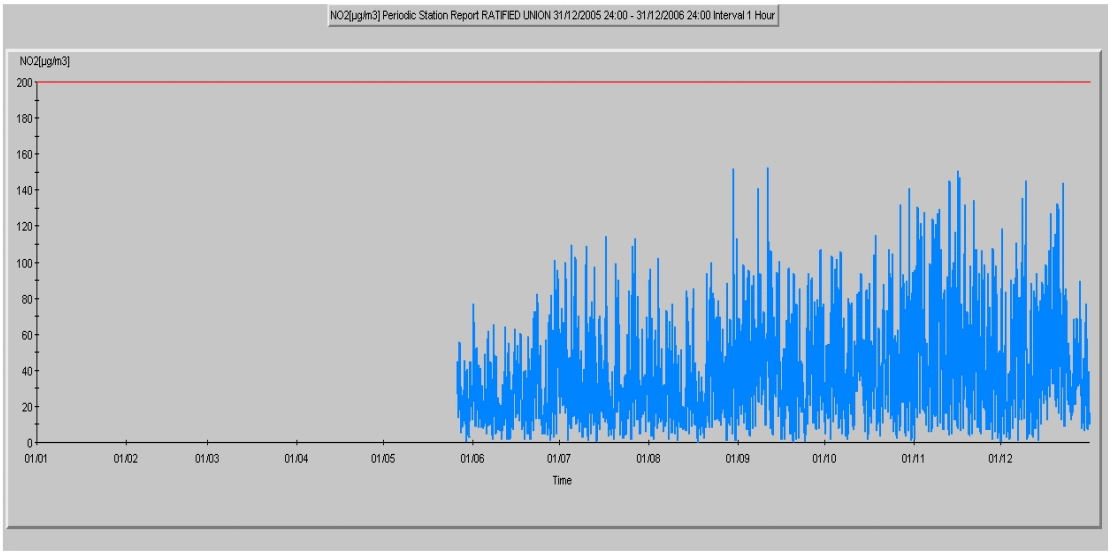
Table 3.2c shows the number of exceedences of the one-hour objective for nitrogen dioxide, and the relevant percentile values (to allow comparison between sites with less than 90% data capture).

Table 3.2c - Number of exceedences of the 1 hour Objective (no more than 18 exceedences of 200 µg/m^3)

Location	2001		2002		2003		2004		2005		2006	
	No. of ex	99.8th %ile (µg/m^3)	No. of ex	99.8th %ile (µg/m^3)	No. of ex	99.8th %ile (µg/m^3)	No of ex	99.8th %ile (µg/m^3)	No. of ex	99.8th %ile (µg/m^3)	No of ex	99.8th %ile (µg/m^3)
Union Street Rollalong	0	155	0	142	1	138	0	137	3	135	0	133
Whitehall St Romon	n/a	n/a	n/a	n/a	n/a	n/a	0	125	1	112	0	106
Seagate Romon	n/a	n/a	n/a	n/a	n/a	n/a	6	180	2	148	0	119
Lochee Road Romon	n/a	n/a	n/a	n/a	n/a	n/a	22	207	0	163	0	141
Groundhog Mains Loan	n/a	n/a	n/a	n/a	n/a	n/a	0	62	n/a	n/a	0	57

The following ***Figures, 3.2(1) to 3.2(5)***, show the time series graphs of hourly average nitrogen dioxide concentrations for each site, for 2006. Data was lost from all monitors (apart from Union St.) in late July and early August as the monitors had to be switched off due to excessive temperatures at this time of the year.

Figure 3.2(1) - Time Series at Union Street of NO_2 Hourly Averages in 2006



A leak in the reaction cell of the NOx analyser was discovered in late May 2006 which meant that data prior to the repair could not be ratified.

Figure 3.2(2) - Time Series at Whitehall St of NO_2 Hourly Averages in 2006

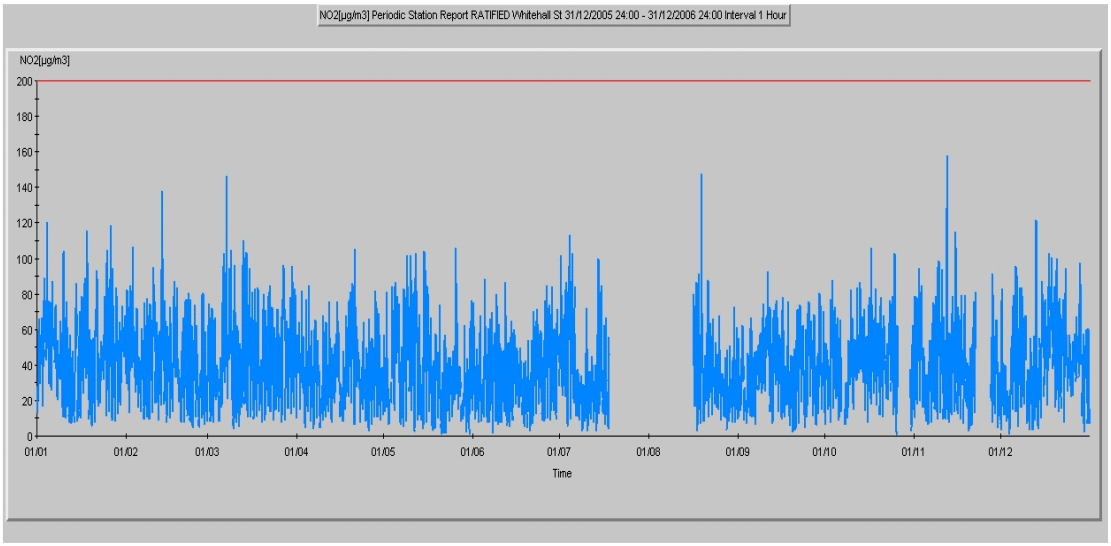
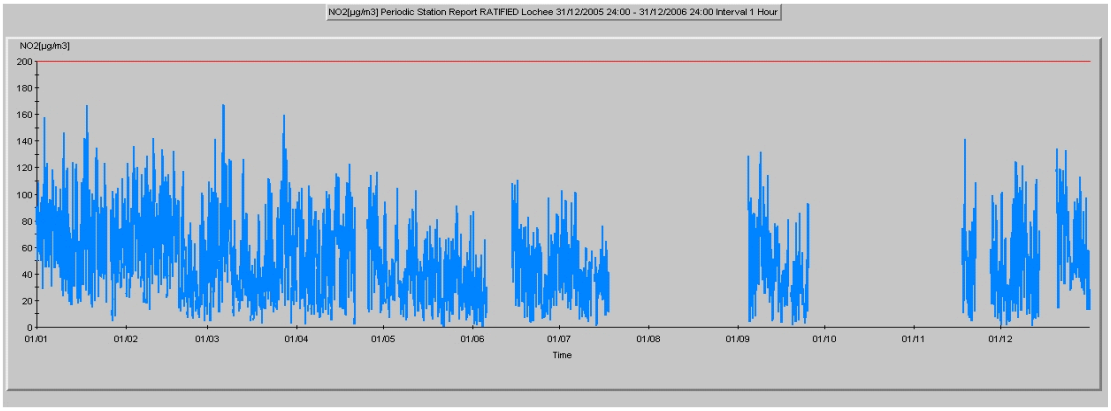
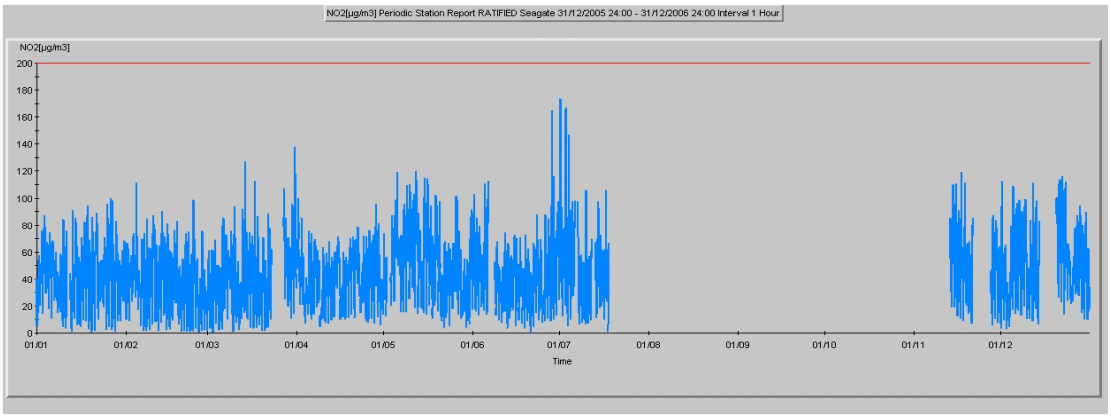


Figure 3.2(3) - Time Series at Lochee Road of NO_2 Hourly Averages in 2006



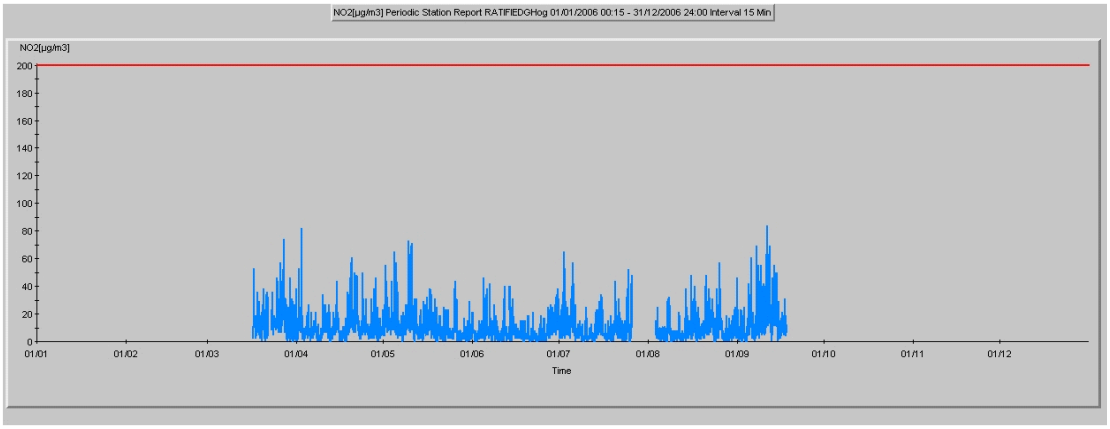
In addition to the switch off due to high temperatures, data was also lost from this monitor due to loss of power in June due to electrical works in the area, and from mid-September to mid-November due to major roadworks close to the monitor associated with the renewal of the gas main.

Figure 3.2(4) - Time Series of Seagate NO_2 Hourly Averages in 2006



Various problems associated with high temperature, heavy rain causing electrical faults, faulty permeation tube, pump and calibration gas flows resulted in data being lost from this monitor.

Figure 3.2(5) - Time Series of Groundhog (Mains Loan) NO_2 Hourly Averages in 2006



The Groundhog is a mobile air quality station which is shared with Angus and Fife Councils, spending approximately 6 months with each local authority. The Groundhog was located in Dundee between 17th March and 17th September 2006.

3.2.1.6 Diurnal NO_2 Concentrations

The following ***Figures* 3.2(6) to 3.2(8)** show the average NO_2 concentrations for each hour of the day in 2006 at each automatic monitoring site. The automatic monitors record the pollution concentrations every 15 minutes against a Greenwich Mean Time (GMT) timebase. The data has been adjusted to take account of the time changes associated with daylight saving and is shown as local time. This adjustment means that the concentrations should more closely reflect the daily cycle of man-made emissions. the diurnal variation in NO_2 concentrations at those sites located close to busy roads and junctions clearly mimics the diurnal pattern of road traffic. The figures highlight the different diurnal patterns that exist on weekdays and Sundays.

Figure 3.2(6) - Comparison of Diurnal Variations All Days at All Sites in 2006

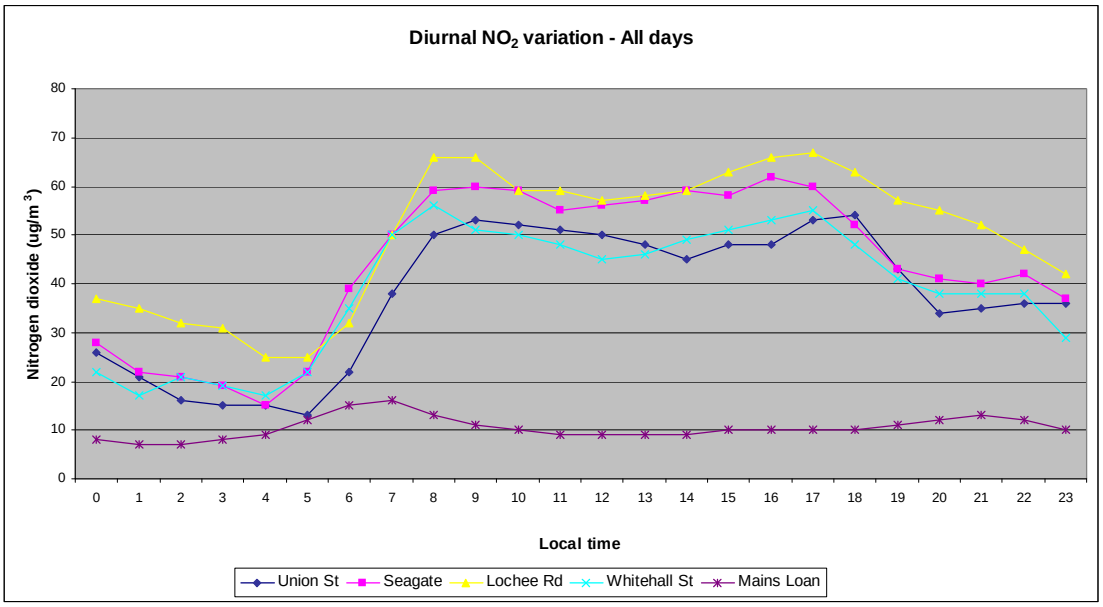


Figure 3.2(7) Comparison of Diurnal Variations Weekdays at All Sites in 2006

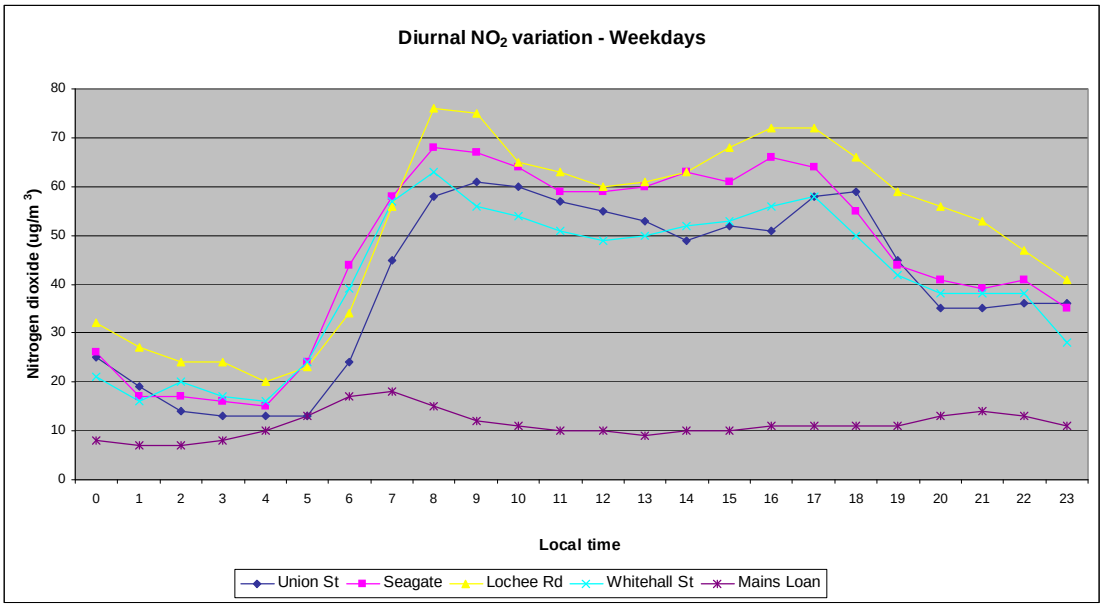
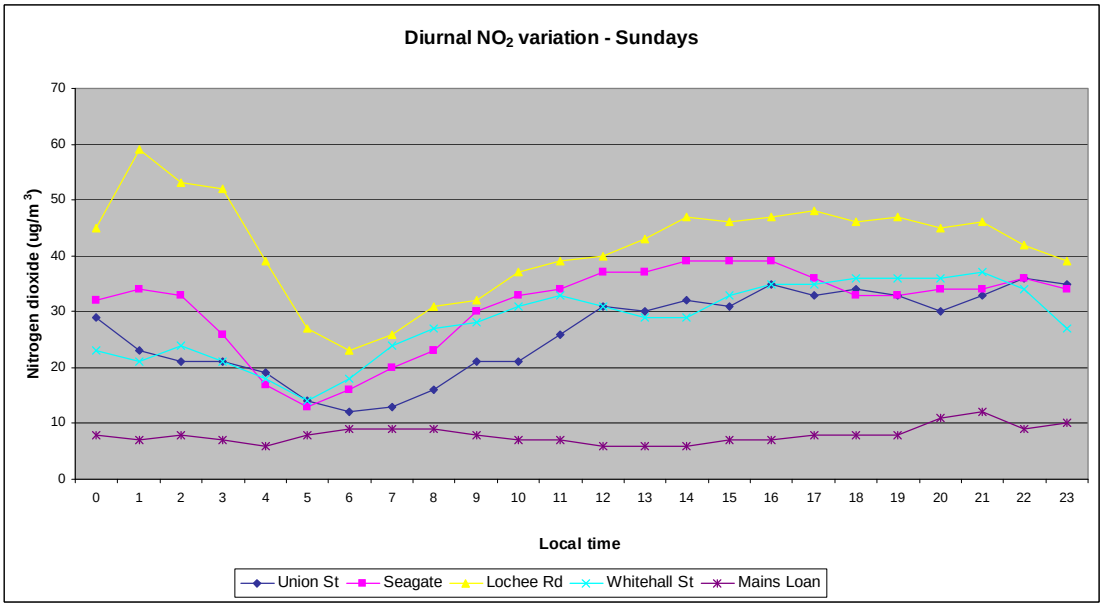


Figure 3.2(8) - Comparison of Diurnal Variations on Sundays at All Sites in 2006



3.2.2 Diffusion Tube Results

3.2.2.1 Measurement Method

The diffusion tubes are supplied by Gradko International and analysed by Dundee City Council Scientific Services using the 20% Triethanolamine (TEA) in water method.

3.2.2.2 Data Quality Requirements

The laboratory method is UKAS[10] accredited and, as the laboratory carries out diffusion tube analysis for the UK NO_2 Network, it is required to participate in the Health and Safety Laboratory's Workplace Analysis Scheme for Proficiency (WASP). The WASP scheme is an independent, internationally recognised performance testing programme. The results achieved by Dundee City Council Scientific Services were found to be consistently "good", in the most recent Network report[11].

Removing any results that visually appear to be spurious, i.e., significantly outwith the expected range, has been carried out during the ratification of the diffusion tube results. The recommended method employed by Dundee City Council Scientific Services to analyse the diffusion tubes typically results in reported concentrations that are slightly higher than concentrations recorded at continuous analysers recorded over comparable time periods (i.e. the tubes overread).

3.2.2.3 Period Mean Adjustment

Results for sites with less than 9 months data cannot be directly compared with the annual mean objective so the data has to be annualised using a period mean adjustment factor. This was carried out in accordance with the statutory guidance[12]. Dundee City Council had three long-term background diffusion tube sites with sufficient data capture in 2006, at Balgavies Place, Birnam Place, and Woodside Avenue, these were used in the calculation of the period mean adjustment factors see **Table 3.2d.**

Table 3.2d - Period mean adjustment factors for 2006 diffusion tube data

Background Site	Annual mean (µg/m³)	Period mean Jun-Dec '06	Ratio (am/pm)	Period Mean Jul-Dec '06	Ratio (am/pm)
Balgavies Pl	**19.6**	19.6	1.000	21.2	0.925
Birnam Pl	**13.2**	12.8	1.033	12.8	1.033
Woodside Ave	**20.0**	18.8	1.063	20.4	0.980
		Average ratio	**1.032**	**Average ratio**	**0.979**

10 UKAS is the United Kingdom Accreditation Service

11 UK Nitrogen Dioxide Network 2003 (AEAT/ENV/R/1926)

12 Department for Environment Food and Rural Affairs and Scottish Executive 2003, 'Part IV of the Environment Act 1995 Local Air Quality Management Technical Guidance LAQM. TG(03), DEFRA Publications. Page A1-16.

3.2.2.4 Calculation of Bias

It is essential that the diffusion tubes are adequately validated against a reference chemiluminescent sample, and that suitable 'bias correction' factors are applied to the data. Dundee City Council has four chemiluminescent analysers measuring NO_2 continuously at various points throughout the city. Three diffusion tubes were co-located with each of the continuous analysers during 2006. The spreadsheet developed by AEAEE[13] has been used to assist in calculating the precision and accuracy (bias) of our diffusion tube collocation studies (**see Appendix 1**). Unfortunately, for the period of this study (January 2006 to December 2006) none of the continuous analysers captured sufficient data to use these bias calculations for diffusion tube validation. In view of this, the bias correction factor calculated by the Review and Assessment Helpdesk[14] for the laboratory analysing the tubes (i.e. Dundee Scientific Services) has been used to bias correct the 2006 tube results[15]. The factor used is 0.78.

3.2.2.5 Summary of Annual Monitoring Results

The results in **Table 3.2e** are for the period 1 January to 31 December 2006 and are period mean adjusted (where necessary), bias corrected and corrected to building façade, to allow direct comparison with the NAQS annual mean for NO_2 (40 μg/m^3) which should have been achieved by 31 December 2005. The results were corrected to represent the level of exposure expected at the façade of the nearest receptor, using adjustment factors supplied by the Review and Assessment Helpdesk operated by Air Quality Consultants and University of West of England, Bristol.

Table 3.2e - NO_2 Diffusion tube results for 2006 (NB Annual mean objective is 40 μg/m^3)

Location	Site type	2006 Annual mean (ug/m^3)	Bias corrected (*0.78)	Approx. level at nearest building façade
Meadowside	R	67.8	52.9	52.9
Victoria Road/Hilltown	R	61.3	47.8	47.8
Logie St (114)	R	60.1	46.9	46.9
Lochee Rd (138)	K	58.3	45.5	43.2
Lochee Rd (140) Traffic Lts	R	58.1	45.3	45.3
Seagate (Romon 3)	K	55.3	43.1	41.0
Whitehall St (Bus)	R	54.9	42.8	40.7
Abertay	K	54.5	42.5	42.5
Seagate (Romon 2)	K	53.8	42.0	39.9

[13] www.airquality.co.uk/archive/laqm/tools/AEA_DifTAB_v03.xls
[14] www.uwe.ac.uk/aqm/review
[15] www.uwe.ac.uk/aqm/review/diffusiontube300907.xls

Location	Site type	2006 Annual mean (ug/m^3)	Bias corrected (*0.78)	Approx. level at nearest building façade
Seagate (Romon 1)	K	53.7	41.9	39.8
Forfar Road	K	51.6	40.2	38.2
Lochee Rd (Romon 2)	K	51.4	40.1	38.1
Nethergate (B&B)(88)	K	51.3	40.0	36.0
Union St (Rollalong 1)	R	50.4	39.3	39.3
Union St (Rollalong 3)	R	50.1	39.1	39.1
Seagate	R	50.0	39.0	39.0
Union St (Rollalong 2)	R	49.8	38.9	38.9
Lochee Rd (Romon 1)	K	49.7	38.8	36.8
Lochee Rd (Romon 3)	K	49.6	38.7	36.7
Whitehall St (Deb A)	K	49.4	38.5	36.6
Kingsway/ Strathmartine Rd (S)	K	47.9	37.4	28.0
Arbroath Rd (13)	K	47.9	37.4	35.5
Dock St (14)	K	47.6	37.1	35.3
Dock St (Carol Whyte) 2	R	46.6	36.3	36.3
Loons Rd (1)	R	46.3	36.1	36.1
Nethergate (Bradford)	R	45.9	35.8	35.8
Broughty Ferry Rd 141	R	45.7	35.6	35.6
Commercial St/Dock St 2	R	45.7	35.6	35.6
Victoria Road (60)	R	45.1	35.2	35.2
Seagate (Yates)(7-9)	R	45.0	35.1	35.1
Strathmore Avenue (353)	K	44.9	35.0	33.3
St Andrews Street (PB)	K	44.9	35.0	33.3
Commercial St (Waterstones)	K	44.7	34.9	33.1
Whitehall St (Tiso)	R	44.7	34.8	34.8
Nethergate (Charlie T)	K	44.6	34.8	33.0
Nethergate (Trades House)	R	44.2	34.5	34.5
Dura St (Forte)	K	43.6	34.0	32.3
Kingsway East Roundabout	R	43.4	33.9	26.8
Whitehall St (Romon 3)	K	43.3	33.7	32.1
Westport (2)	R	43.0	33.6	33.6
Clep Rd/ Forfar Rd	K	43.0	33.5	30.2
Whitehall St (Romon 1)	K	42.7	33.3	31.7
Dock St (Unicorn)	R	42.7	33.3	33.3
St Andrews St (JAF)	K	41.9	32.7	31.1
Logie St (98)	K	41.9	32.7	31.0
Whitehall St (Romon 2)	K	41.7	32.5	30.9
Albert St (Shandon Pl)	R	41.4	32.3	30.7
Whitehall St (Deb E)	K	41.3	32.2	30.6
Whitehall St (BRJ)	K	41.2	32.2	30.6
Victoria Road	R	41.2	32.1	32.1
Albert St 1	K	41.2	32.1	30.5

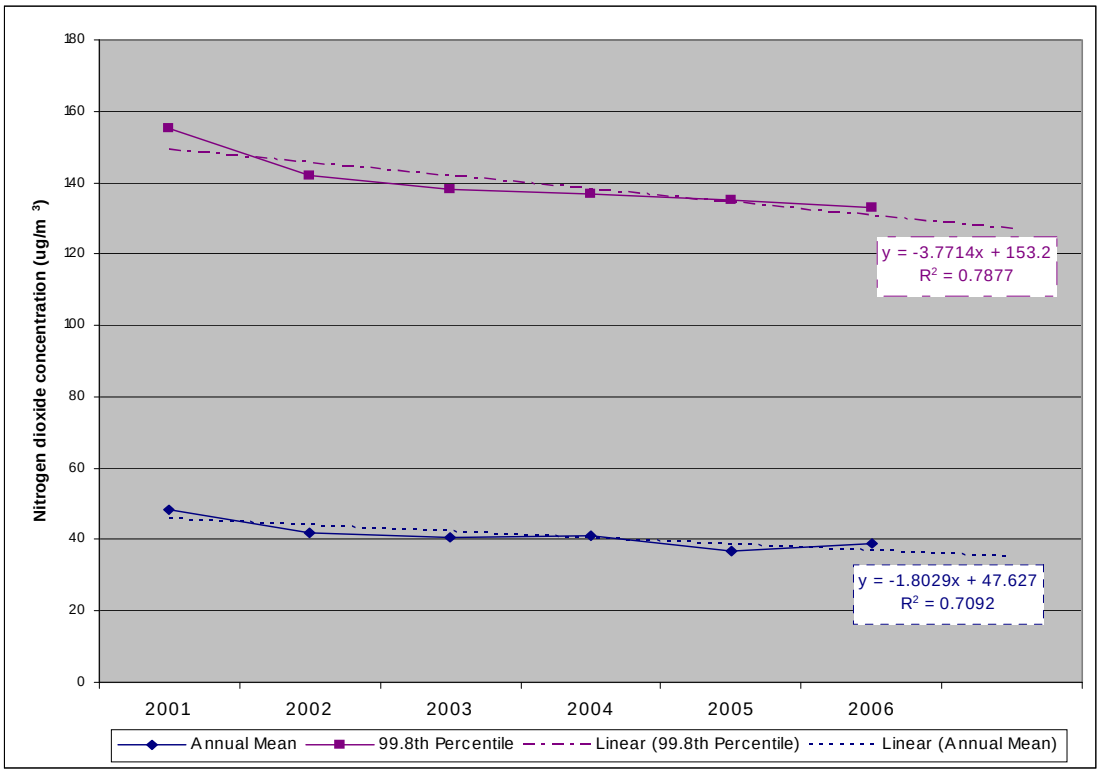
Location	Site type	2006 Annual mean (ug/m^3)	Bias corrected (*0.78)	Approx. level at nearest building façade
Lochee Rd (184)	K	**40.9**	31.9	30.3
Victoria Street	K	**40.7**	31.7	30.2
Rankine Street (2)	R	**40.6**	31.7	31.7
Commercial St	K	**40.1**	31.3	29.7
Victoria Road / Cotton Road	K	**40.1**	31.3	29.7
Hilltown (Suites)	R	**39.7**	31.0	31.0
Eastport Roundabout	R	**39.1**	30.5	30.5
Dens Rd (Crossing)	R	**38.7**	30.2	28.7
Albert St (Fish)	K	**38.4**	30.0	28.5
Kingsway/ Mains Loan	R	**38.4**	29.9	23.7
Nethergate/ Marketgait	R	**38.2**	29.8	28.3
Victoria Road (10)	R	**38.1**	29.7	29.7
Soapwork Lane	R	**37.9**	29.6	29.6
Marketgait	R	**37.5**	29.3	29.3
Trades Lane (31)	K	**37.5**	29.2	27.8
Harefield Rd (35)	K	**37.4**	29.2	21.9
Union Street (Mcintyres)	K	**37.2**	29.0	27.6
Crichton St	K	**36.7**	28.6	27.2
Union Street (Goodfellows)	K	**36.2**	28.2	26.8
Myrekirk Road	K	35.2	27.5	20.6
Whitehall Cr (Xpresso)	K	34.9	27.2	25.9
Lochee Rd/Polepark Rd	K	34.3	26.8	24.1
Kingsway/ Pitkerro Rd	R	34.1	26.6	22.1
Bank St/ Reform St	K	33.9	26.4	25.1
King St (12 & 14)	K	33.9	26.4	25.1
Muirton Road (6)	R	33.4	26.1	26.1
Nethergate/South Tay St	R	32.6	25.4	25.4
Perth Road/Hawkhill	K	30.1	23.5	22.3
Claypotts Junction	R	29.1	22.7	22.7
Arthurstone Tce 10	K	29.0	22.6	21.5
Brook St B/F	K	27.9	21.8	20.7
Earl Grey Pl (Park)	UB	25.9	20.2	20.2
St Mary Flats	R	23.6	18.4	14.5
Woodside Avenue	UB	20.0	15.6	15.6
Balgavies Pl	UB	19.6	15.3	15.3
Birnam Pl	UB	12.3	9.6	9.6

K = kerbside, R = roadside, B = urban background
Note: The 3 coloured locations are highlighted to indicate the period adjustment factor used (see **Table 3.2d**)

3.2.3 Trends in NO_2 Concentrations

Trends in concentrations are normally shown for sites with at least five years of measurement data; the longest period of automatic measurement available in Dundee is the five years at Union Street. A graph showing the trends in the annual mean and percentile values is shown in ***Figure 3.2(9).***

Figure 3.2(9) - Trends in NO_2 Annual means and 99.8th Percentiles at Union Street 2001- 2006



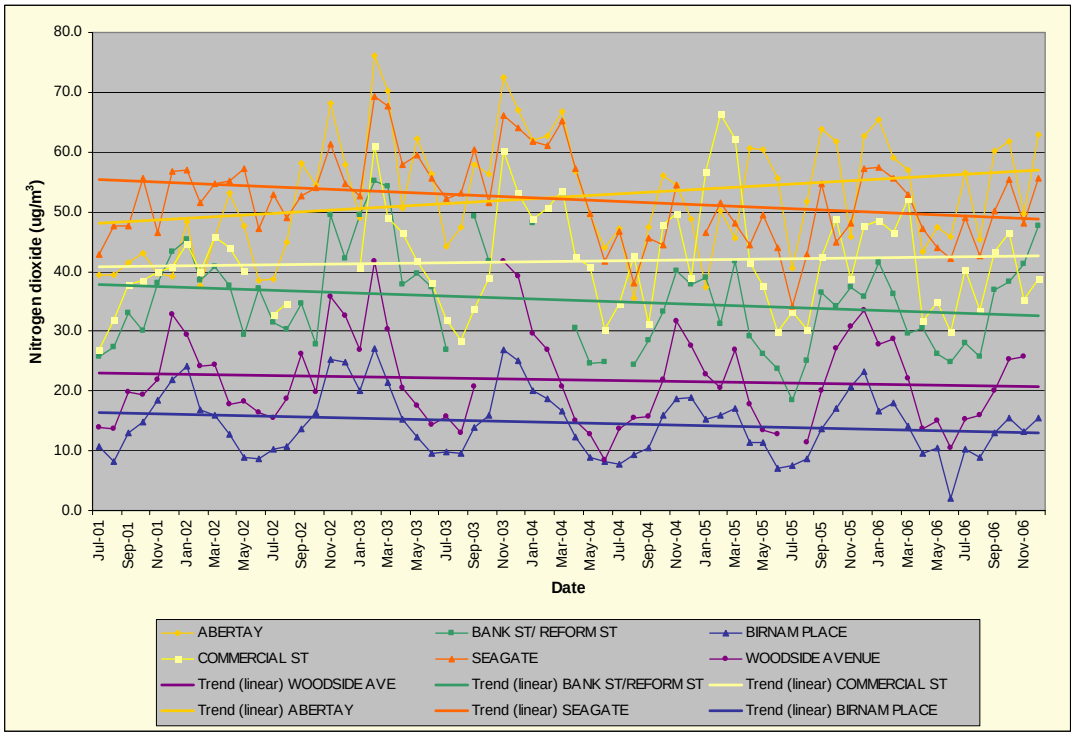
R^2 - Is the coefficient of determination and is an indicator that ranges in value from 0 to 1. It reveals how closely the estimated values for the trendline correspond to the actual data. A trendline is most reliable when its R-squared value is at or near 1.
NB - NAQS Annual Mean is 40 µg/m³, NAQS 1 hr mean is 200 µg/m³.

Figure 3.2(9) shows a downward trend for both the measured annual mean and 99.8th percentile at the Union Street monitor. It should be noted that the ***Figure 3.2(9)*** is based on unratified data for 2001-2004. The 99.8th percentile values have always been below 200 µg/m³ . However the annual mean values only dropped below 40 µg/m³ in 2005 but then rose slightly in 2006. It is less certain that this downward trend will be maintained and monitoring shall need to be continued.

There are six diffusion tube sites in Dundee that have been operational since 1995 (Abertay, Bank Street/Reform Street, Balgavies Place, Birnam Place, Commercial Street, Seagate and Woodside Avenue). Unfortunately, due to

adoption of the national recommended change in diffusion tube analysis, it is only possible to show trends from July 2001, see ***Figure 3.2(10).***

Figure 3.2(10) - Trends in monthly NO_2 concentrations at long-term diffusion tube locations, July 2001 – Dec 2006 (no bias factors applied)



When viewing monthly data it is important to recognise that NO_2 results fluctuate through the year, with lower levels recorded during the summer months. By addition of trend lines, the levels at the two background sites (Birnam Place and Woodside Avenue), Bank Street/Reform Street and Seagate can be seen to be decreasing slightly. The levels at Abertay and Commercial Street are increasing and as these are roadside locations this is likely to be due to changes in traffic flows (e.g. numbers or types of vehicles using the road).

NO_2 diffusion tube monitoring has been undertaken in Dundee since 1993. In general, the annual mean NO_2 concentrations of the diffusion tube results exhibit a decreasing trend in accordance with national trends and government predictions. However, local changes to traffic management and increases in vehicle flow can have a greater influence on recorded pollutant concentrations and may counteract the effects of the national measures to reduce emissions.

3.2.3.1 Background Concentrations

The NO_2 annual mean concentrations for 2006, at urban background monitoring sites were found to be in generally good agreement with the

estimated background concentrations that are available from the national online UK Air Quality Archive (AQ Archive) database (see **Table 3.2f**).

Table 3.2f - Comparison of Measured Background Results for 2006 with the new AQ Archive estimated background concentrations for 2006.

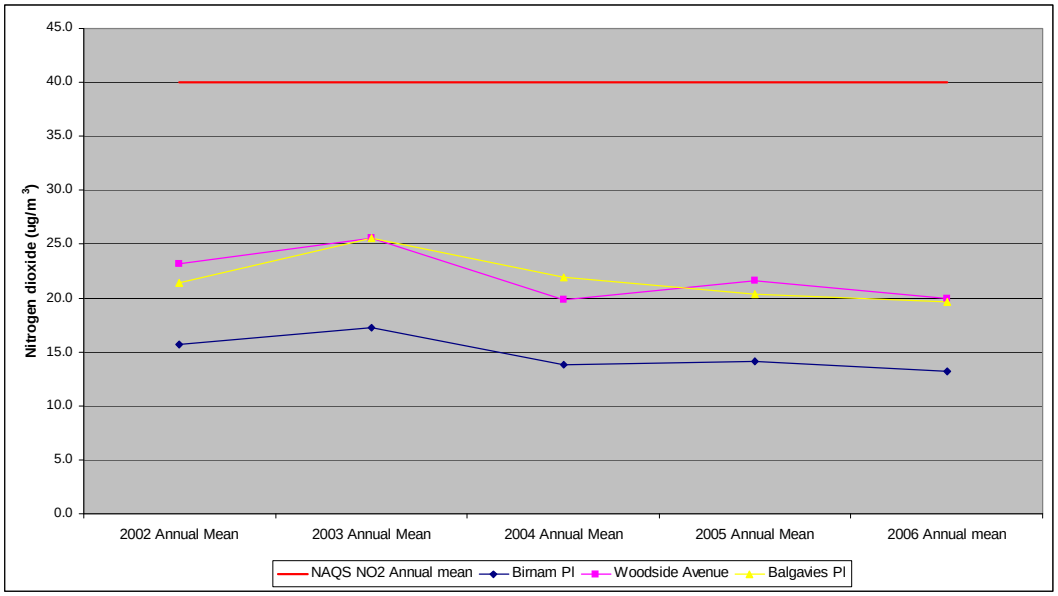
Location	Measured Annual Mean 2006 (0.78 Bias) (µg/m^3)	AQ Archive estimated Annual Mean (2006) (µg/m^3)
Balgavies Place	14.9	10.8
Birnam Place	9.3	10.5
Woodside Avenue	15.2	15.9
Groundhog	12.2	17.3

It can be seen that ambient background NO_2 concentrations in Dundee are low and well below the NAQS.

Some disparity can be seen between the 'measured' and 'estimated' concentrations at Balgavies Place and the Groundhog locations. Although the Groundhog uses the reference method it was only present for 6 months so the data had to be annualised. It is notable that the concentration measured at Balgavies Place is in better agreement with the previous AQ Archive estimate of 14.6 µg/m³ for grid 343500:731500 than the current estimate of 10.8 µg/m³.

Figure 3.2(11) shows the changes in uncorrected NO_2 concentrations in background diffusion tubes over the past 4 years.

Figure 3.2(11) - Annual Measured NO_2 Concentrations at Diffusion Tubes in Urban Background Locations



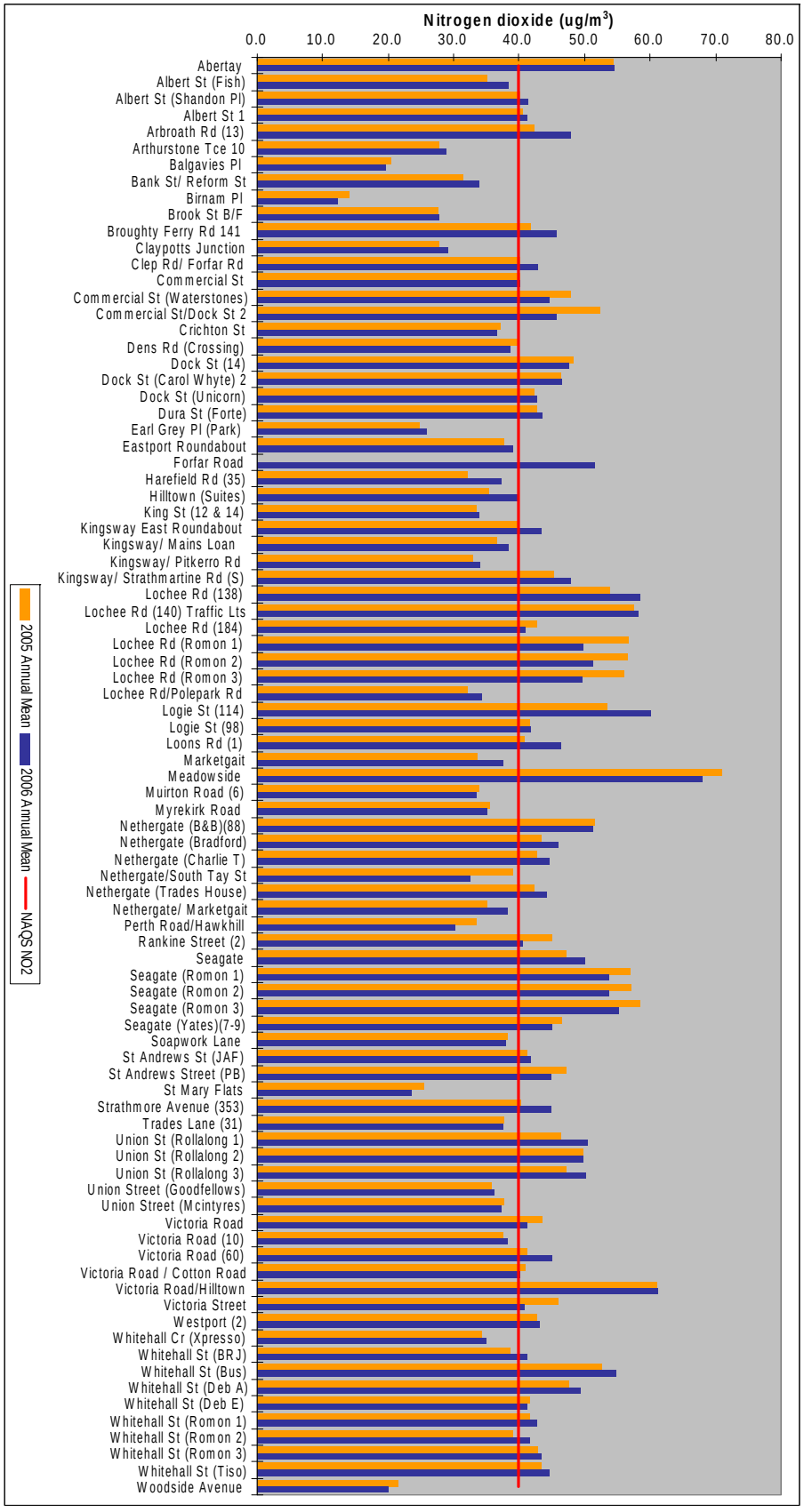
The annual means measured at background locations generally show a decline since 2003 which was a higher than usual pollution year. As these sites are not directly influenced by direct sources of NO_2, it is considered that the decrease in concentration reflects the cumulative effects of Government and EU policies and legislation to reduce pollutant emissions.

3.2.4 Discussion of Results

The bias corrected measured annual mean results in 2006 are directly comparable with the NAQS annual mean for NO_2 (40 µg/m^3) and do not need to be predicted forward as the target date for achieving this NAQS was 31st December 2005.

However, the bias correction factor applied to tube results for 2006 (0.78) is different from the factor used in 2005 (0.76). So to compare 2006 with previous years the actual measured (un-bias corrected) results are shown. ***Figure 3.2(12)*** shows a comparison of the actual measured results for both 2005 and 2006. Using this method of comparison it has been observed that 54 out of the 87 tubes (62%) have shown an increase in NO_2 concentration since 2005.

Figure 3.2(12) - Comparison of Measured Annual Mean NO_2 results at Diffusion Tube Locations in 2005 and 2006



The technical guidance advises that if the annual mean concentration exceeds 60 ug/m^3, it can be taken as a reliable indication that the 1-hour mean will be exceeded at that location. None of the bias corrected diffusion tube annual means (see **Table 3f)** exceed 60 ug/m^3 and hence no exceedences of the 1-hour mean are predicted. In addition none of the continuous analysers recorded an exceedence of the 1-hour mean during their periods of operation in 2006. Although this is the first year since 2003 that no 1-hour mean exceedences were recorded, this could be as a consequence of poor data capture at the analysers, as can be seen in **Figure 3.2(1) to Figure 3.2(5).**

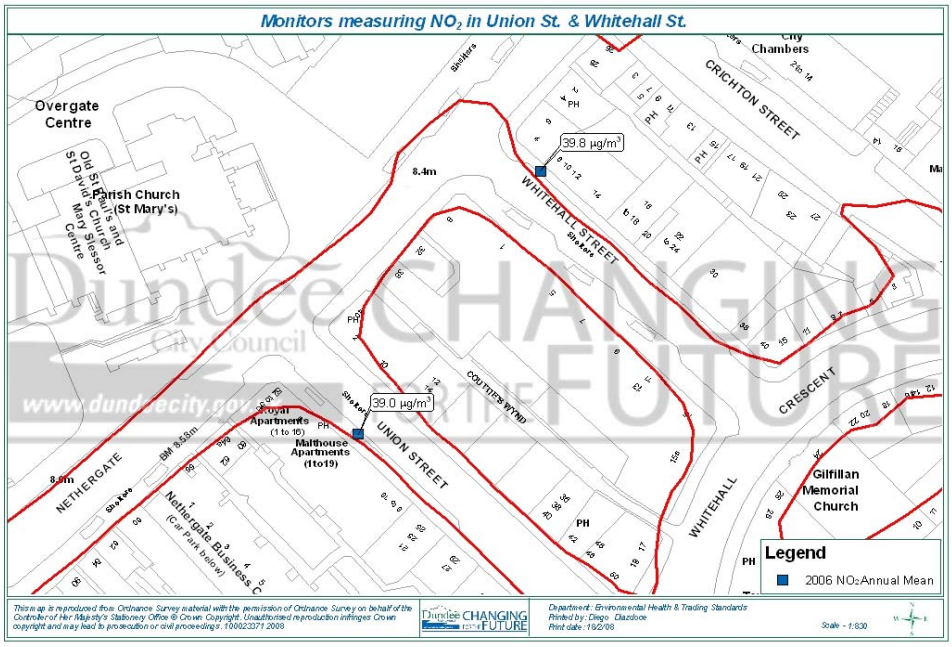
Due to the inherent uncertainties in the measurement methods used to analyse the tubes and in the derivation of the bias correction factors, all tubes with a predicted annual mean above 36 µg/m^3 have been considered as areas of potential exceedence: and these are discussed below.

The figures below show the annualised mean for the automatic monitors and the bias corrected annual mean tube results for 2006. Where appropriate the figures also show the areas of exceedence of the NO_2 annual mean objective (the red lines) predicted in the council's detailed assessment (i.e. above 36 µg/m^3) (March 2005). Results are also compared, where relevant, with the 2005 results from the council's 'Updating & Screening Assessment' (2006).

3.2.4.1 Union Street

Union Street is a street canyon and one of the main bus corridors in the city centre. There is residential exposure from first floor upwards in this street.

Figure 3.2(13) - Nitrogen Dioxide Monitors in Union Street & Whitehall Street

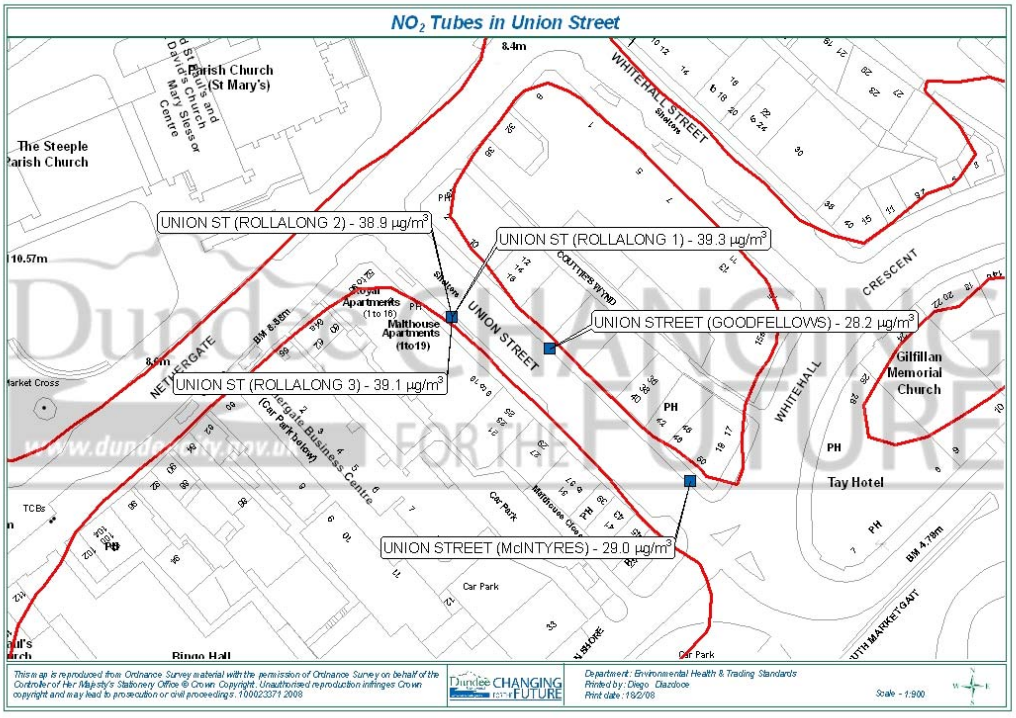


The monitor is located near the top of the street on the west side between two bus stops **(Figure 3.2(13)).** The measured 2006 annual mean (39.0 µg/m^3) is less than the annual mean objective of 40 µg/m^3 based on annualised 6 months data. This has increased from 36.6 µg/m^3 in 2005.

Pollutant concentrations can fluctuate from year to year for a number of reasons. This is the first year for a while that there has not been significant roadworks in Union Street and is the first year of results since the construction of a temporary 120 space car park on Yeaman Shore at the bottom of Union Street. Unfortunately, as it is difficult to locate automatic traffic counters in busy city centre streets it is not possible to directly equate the fluctuating traffic flows in this area with the locally recorded nitrogen dioxide level.

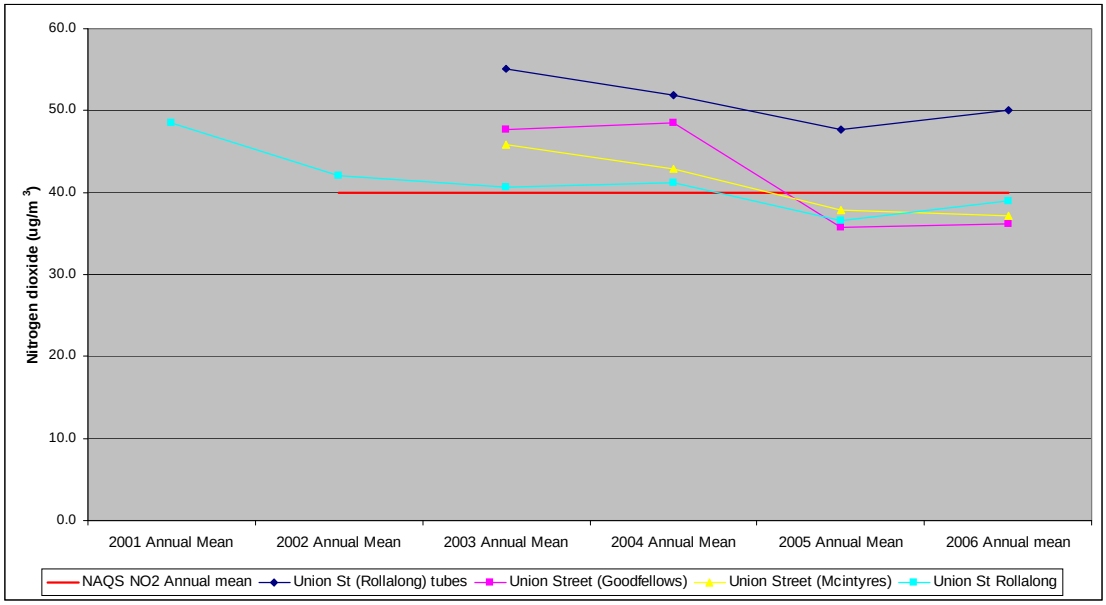
There were no recorded exceedences of the hourly objective for nitrogen dioxide (200 µg/m^3) at the Union Street monitor during 2006. Eighteen exceedences of the hourly objective are permitted.

Figure 3.2(14) - Nitrogen Dioxide tubes in Union Street



The bias corrected Union Street Rollalong diffusion tube results (39.3, 38.9, 39.1 µg/m^3) are in good agreement with the annualised mean recorded at the continuous monitor in this street (39.0 µg/m^3) **(Figure 3.2(14))**. Other tubes in Union Street are below the annual mean objective. All the Union Street tubes lie within the area of exceedence predicted in the detailed assessment but only those co-located with the continuous analyser are above 36 µg/m^3. ***Figure 3.2(15)*** shows the changes in real-time monitor and uncorrected NO_2 concentrations in diffusion tubes in this area over the past 4 years.

Figure 3.2(15) - Annual Measured NO_2 Concentrations in Union Street

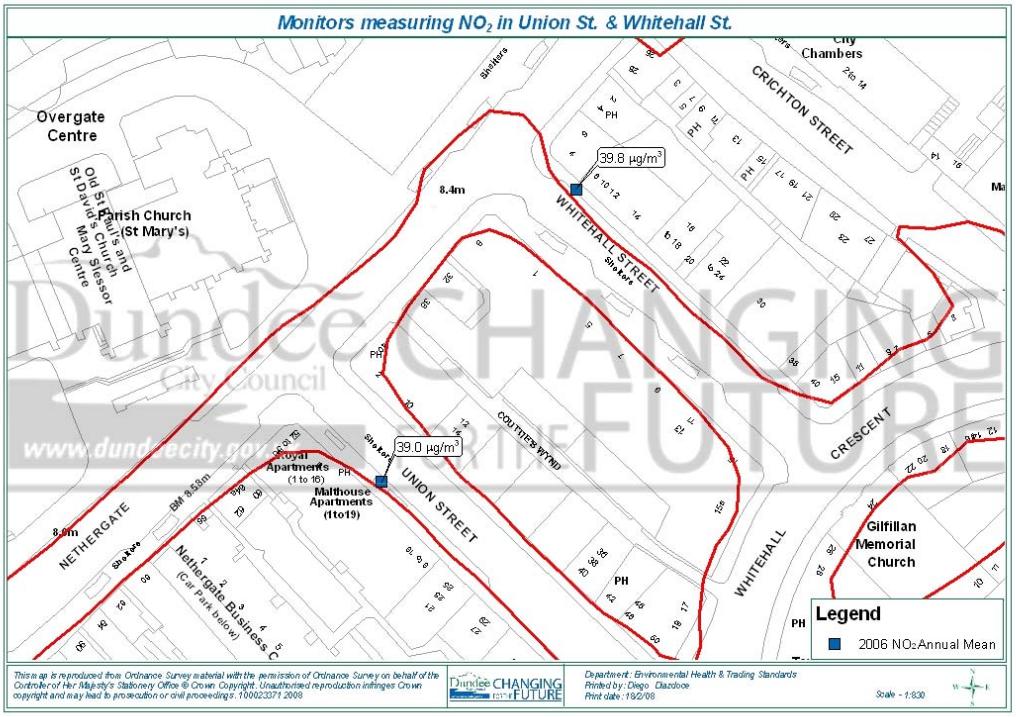


The tubes on the southbound side of Union St. have shown a decrease in recent years, this is thought to be because the tubes have been moved slightly closer to the building façade, and because of some lengthy southbound lane closures. The Rollalong results also show a general decline but only the 2006 results have been ratified.

3.2.4.2 Whitehall Street

Whitehall Street is a street canyon and one of the main bus corridors in the city centre and contains a recently constructed bus interchange. There is residential exposure from first floor upwards in this street. The monitor is located near the top of the street on the east side, adjacent to a parking bay which is set back from the road **(Figure 3.2(16))**.

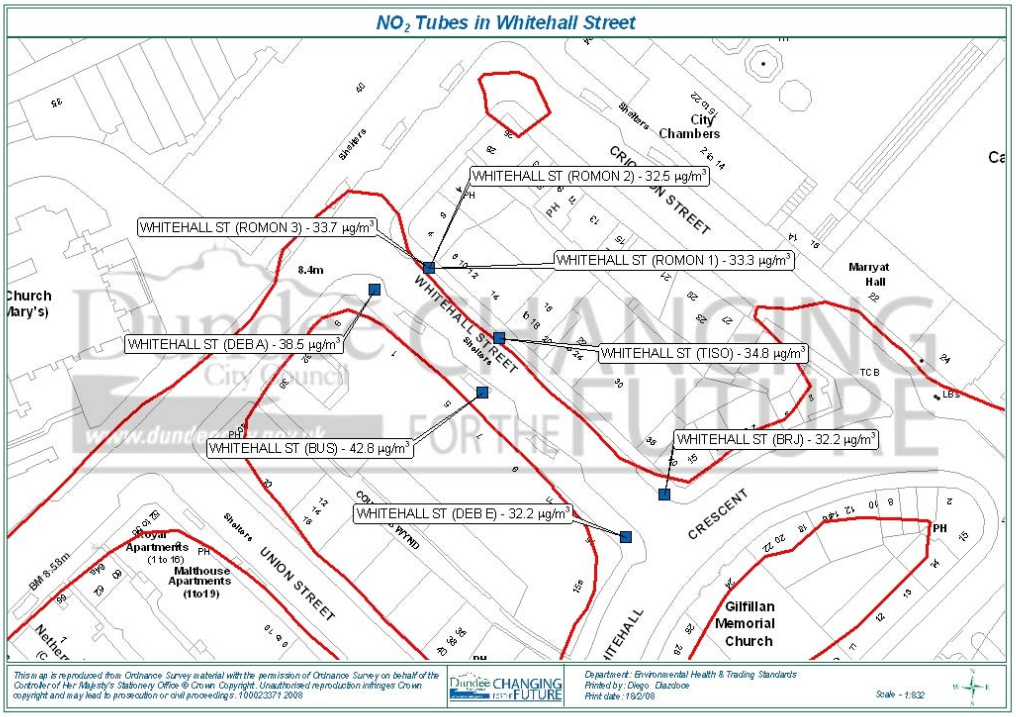
Figure 3.2(16) - Nitrogen Dioxide Monitor in Whitehall Street



The measured annual mean in 2006 (39.8 µg/m^3) is slightly greater than that measured in 2005 (39.4 µg/m^3) and just below the annual mean objective of 40 µg/m^3.

There were no exceedences of the hourly objective for nitrogen dioxide (200 µg/m^3) recorded in 2006. Eighteen exceedences of the hourly objective are permitted.

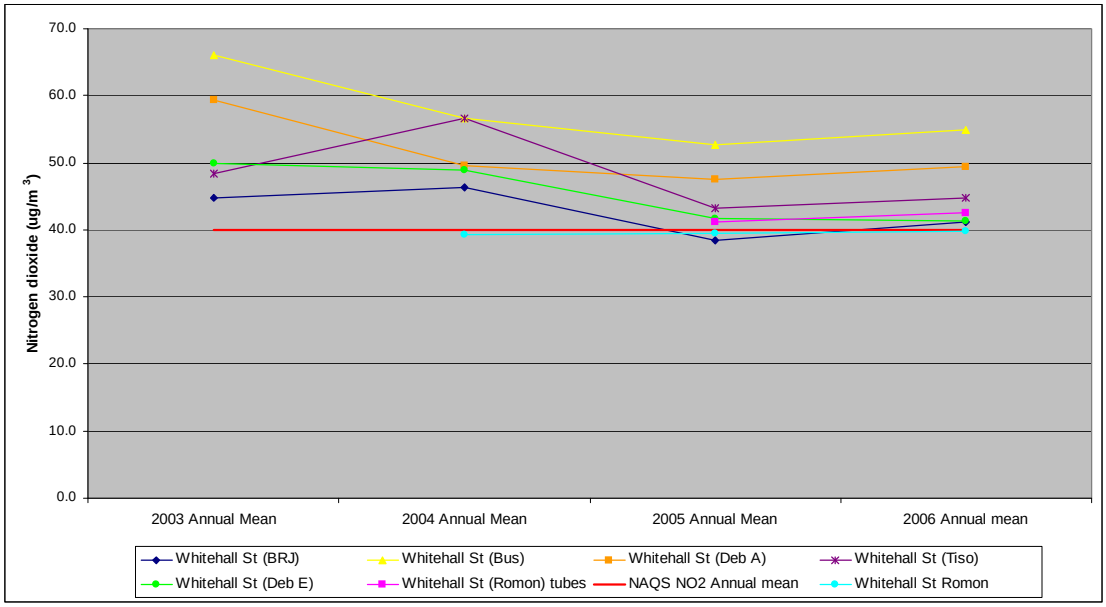
Figure 3.2(17) - Nitrogen Dioxide tubes in Whitehall Street



The 0.78 bias corrected annual mean results for the three Whitehall Street tubes **(Figure 3.2(17))** located with the monitor (Romon 1,2,3: 33.3, 32.5, 33.7µg/m^3) are below the annual mean recorded by the continuous monitor in Whitehall Street (39.8 µg/m^3). Of the Whitehall Street tubes located within the area of exceedence predicted in the detailed assessment, only 'Deb A' (38.5µg/m^3) and 'Bus' (42.8µg/m^3) are above 36µg/m^3. However, NO_2 concentrations have increased at all Whitehall Street tubes, apart from 'Deb E', since 2005 (see **Figure 3.2(12)**). This area has been identified in previous assessments and is within the AQMA.

Figure 3.2(18) shows the changes in real-time monitor and uncorrected NO_2 concentrations in diffusion tubes in this area over the past 4 years.

Figure 3.2(18) - Annual Measured NO_2 Concentrations in Whitehall Street

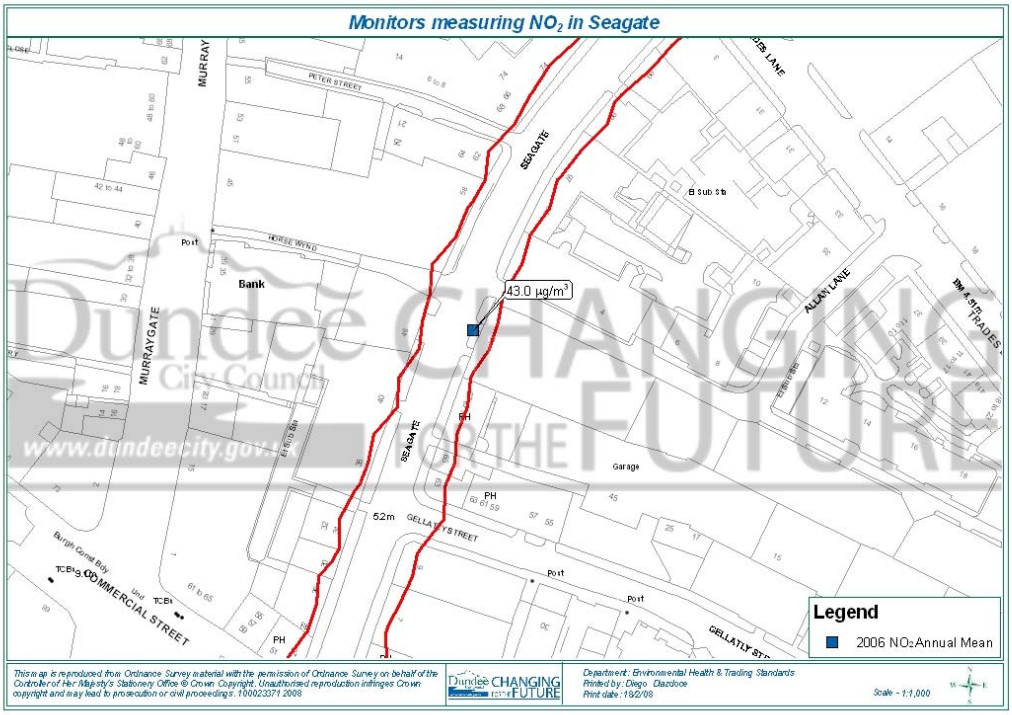


The Whitehall Street tubes generally show a decline since 2003 which was a higher than usual pollution year but appear to increase again 2006. The ROMON results have remained relatively stable although only the 2006 results have been ratified.

3.2.4.3 Seagate

Seagate is a narrow congested street canyon, on the main bus corridor through the city centre, with residential exposure at ground level in several locations.

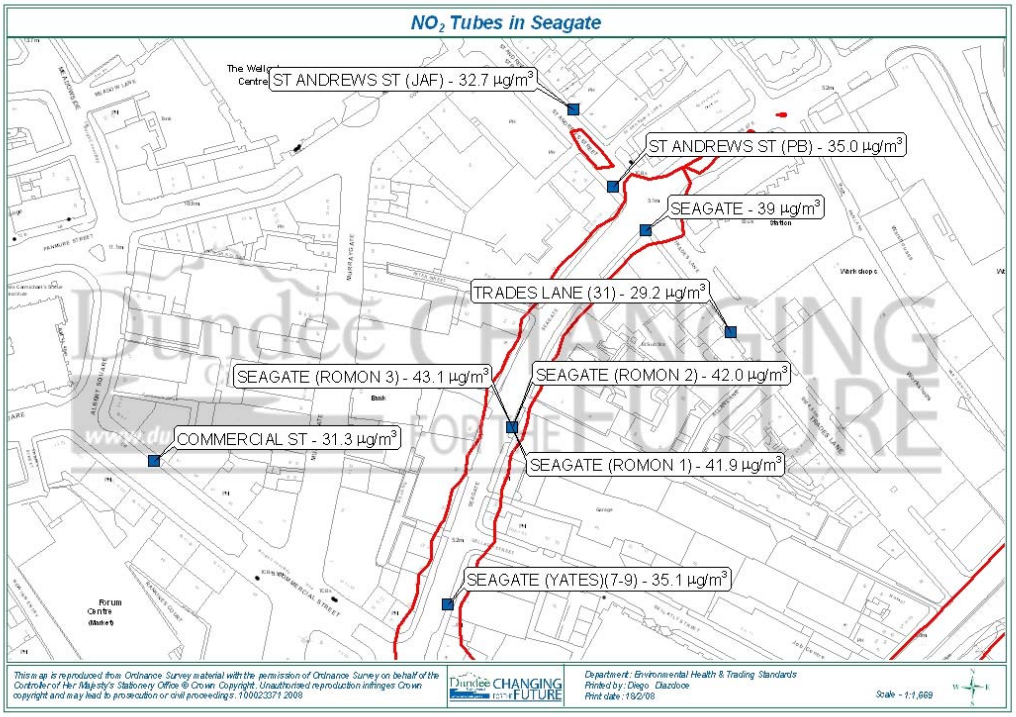
Figure 3.2(19) - NO_2 Monitor in Seagate.



The monitor is located approx. half way along the Seagate on the east side and is adjacent to a loading bay **(Figure 3.2(19))**. The measured annual mean in 2006 (43.0 µg/m^3) is significantly lower than measured in 2005 (59.9 µg/m^3) but above the annual mean objective of 40 µg/m^3. The reduction in NO_2 levels at this location is thought to be mostly due to improved data ratification procedures.

There were no exceedences of the hourly objective for nitrogen dioxide (200 µg/m^3) recorded at the Seagate monitor in 2006. Eighteen exceedences of the hourly objective are permitted.

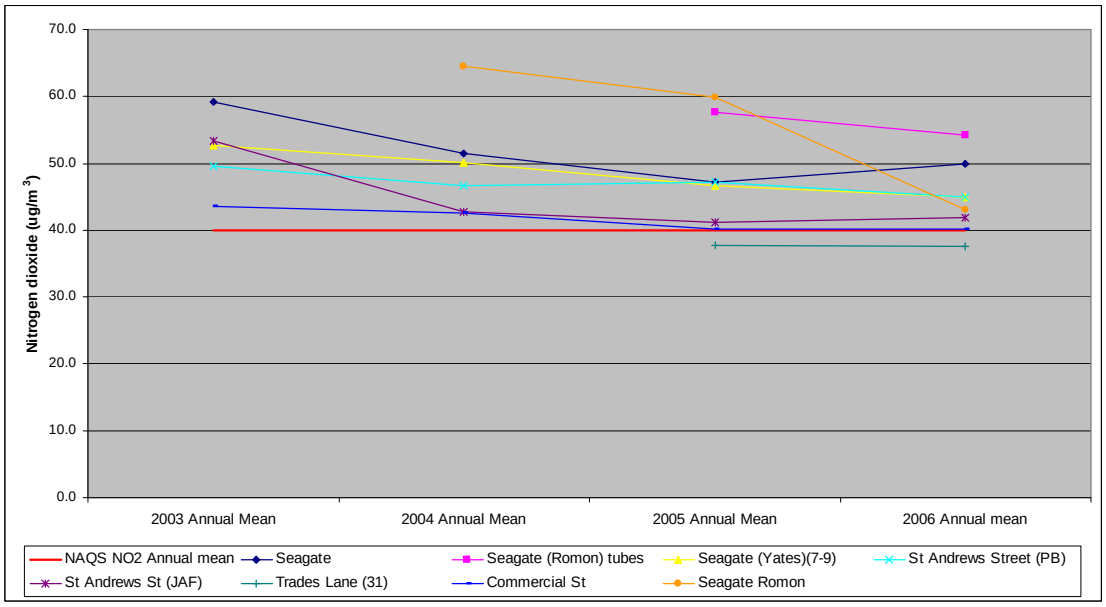
Figure 3.2(20) - Nitrogen Dioxide tubes in Seagate



The average annual mean results of those diffusion tubes located with the monitor in the Seagate **(Figure 3.2(20))**, (Romon1,2 & 3) is 42.3 µg/m^3 (0.78 bias corrected) and compares well with the annual mean recorded at the continuous monitor in Seagate (43.0 µg/m^3). Although the other Seagate tubes are situated closer to controlled junctions they record lower concentrations of NO_2 than those next to the monitor. However the monitor is located in the centre of the street canyon, at kerbside, where dispersion of pollutants is impeded.

Figure 3.2(21) shows the changes in real-time monitor and uncorrected NO_2 concentrations in diffusion tubes in this area over the past 4 years.

Figure 3.2(21) - Annual Measured NO_2 Concentrations in Seagate

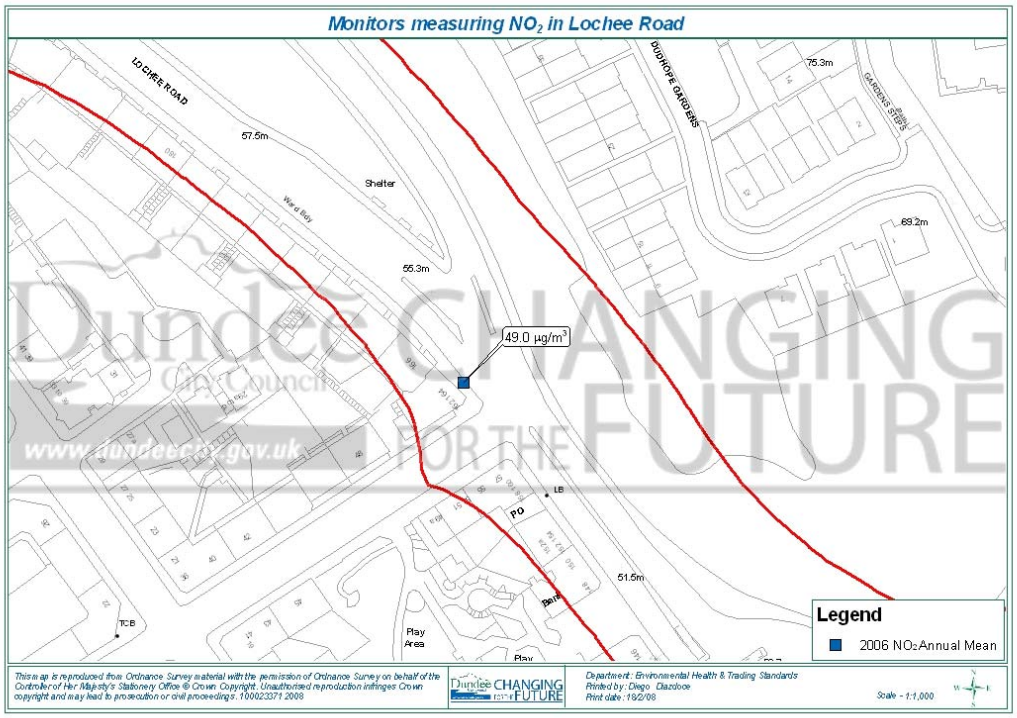


The Seagate tubes generally show a decline since 2003 which was a higher than usual pollution year but some appear to increase again 2006. The dramatic fall in results recorded by ROMON is thought to be mostly due to improved data ratification procedures.

3.2.4.4 Lochee Road

Lochee Road is part of the main north-west arterial route, and tubes are located close to the busy junctions with Rankine Street and Dudhope Terrace **(Figure 3.2(22))**. There is residential exposure from ground floor upwards in this area. The road has a steep gradient and although not a classic street canyon it is bounded on the west side by 4 storey tenement buildings and on the east side by steeply rising ground.

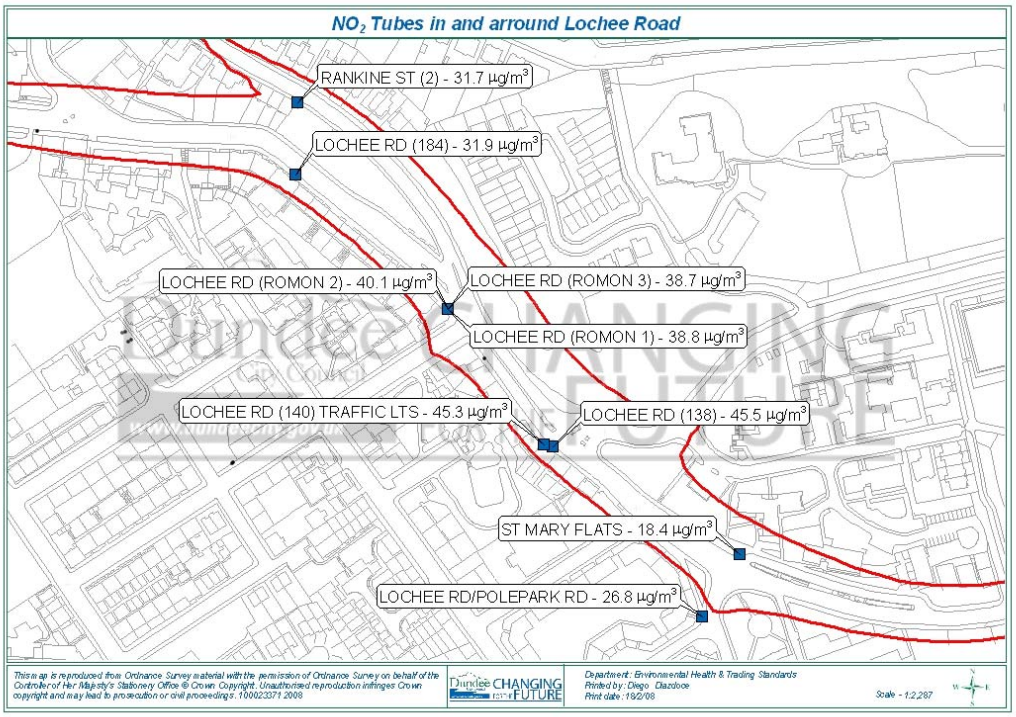
Figure 3.2(22) - NO_2 Monitor in Lochee Road



The measured annual mean in 2006 (49.0 µg/m^3) is significantly lower than measured in 2005 (67.7 µg/m^3) but above the annual mean objective of 40 µg/m^3. The reduction in NO_2 levels at this location is thought to be mostly due to improved data ratification procedures.

There were no exceedences of the hourly objective for nitrogen dioxide (200 µg/m^3) recorded in 2005. Eighteen exceedences of the hourly objective are permitted

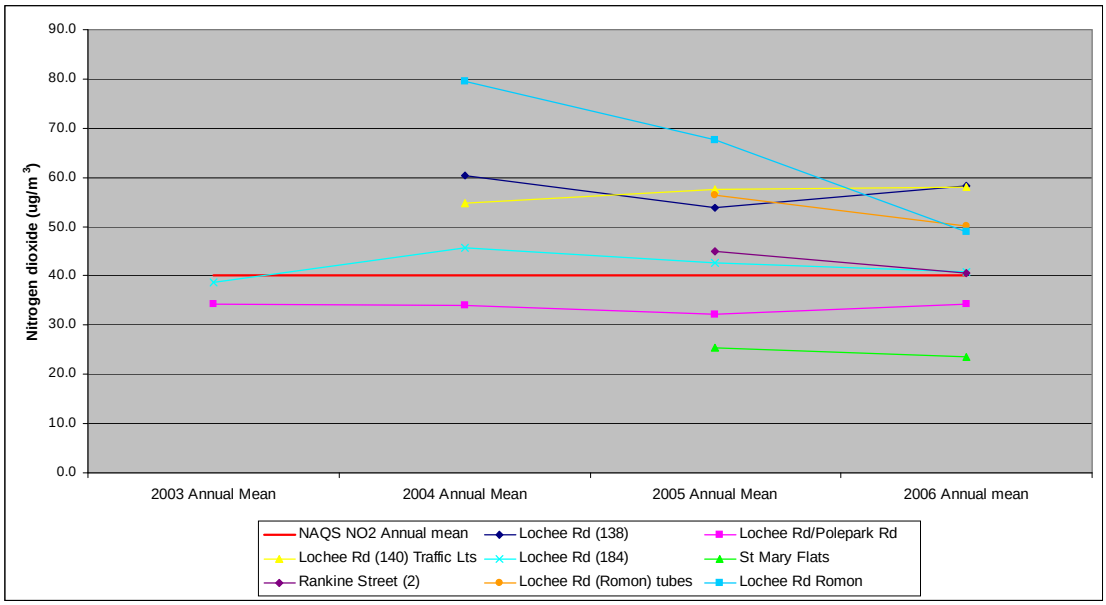
Figure 3.2(23) - Nitrogen Dioxide tubes in Lochee Road



The average annual mean results of the three Romon tubes located with the monitor in Lochee Road is 39.2 µg/m^3 (0.78 bias corrected) and does not compare well with the annual mean recorded at the continuous monitor (49.0 µg/m^3). In order to determine the extent of this area of exceedence, a number of tubes have been located along this stretch of Lochee Road **(Figure 3.2(23))**. The tube results show that the highest levels of pollution are found between the controlled junction with Dudhope Terrace and the Rankine Street junction, and only these tubes are greater than 36 µg/m^3, despite most of the tubes being within the predicted exceedence line. According to tube results, NO_2 concentrations return to acceptable levels by Polepark Road, to the south, and Tullideph Road to the north of the area of exceedence. It is worth noting that the result for Lochee Road (140) 45.3 µg/m^3, which is located at the building facade does not show the expected reduction in NO_2 levels from Lochee Road (138) 45.5 µg/m^3, which is located at the kerbside. This area has been identified in previous assessments and is within the AQMA.

Figure 3.2(24) shows the changes in real-time monitor and uncorrected NO_2 concentrations in diffusion tubes in this area over the past 4 years.

Figure 3.2(24) - Annual Measured NO_2 Concentrations in Lochee Road

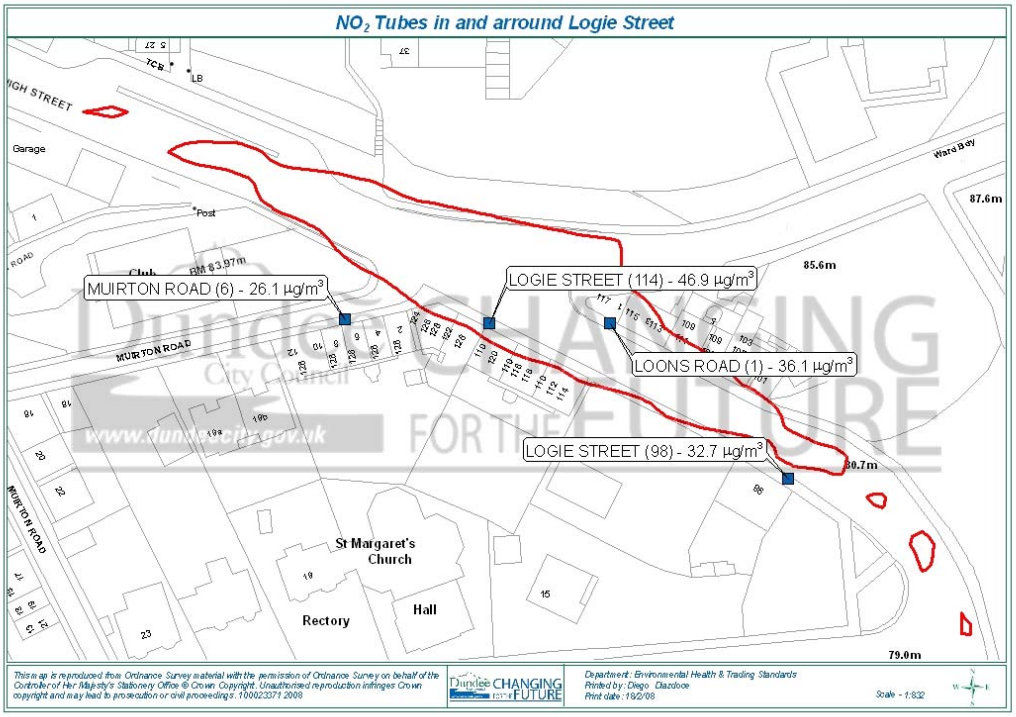


The tubes located on Lochee Road between Dudhope Terrace and Rankine Street remain the highest. Tubes either side of this junction are fluctuating from year to year. There is insufficient data to establish any clear trend at this location.

3.2.4.5 Logie Street/Loons Road

The Logie Street/Loons Road junction is a busy controlled junction on the north west arterial route for the city. There are 3-storey buildings on either side of the junction with residential exposure from first floor upwards and new ground floor residential proposed close to the junction.

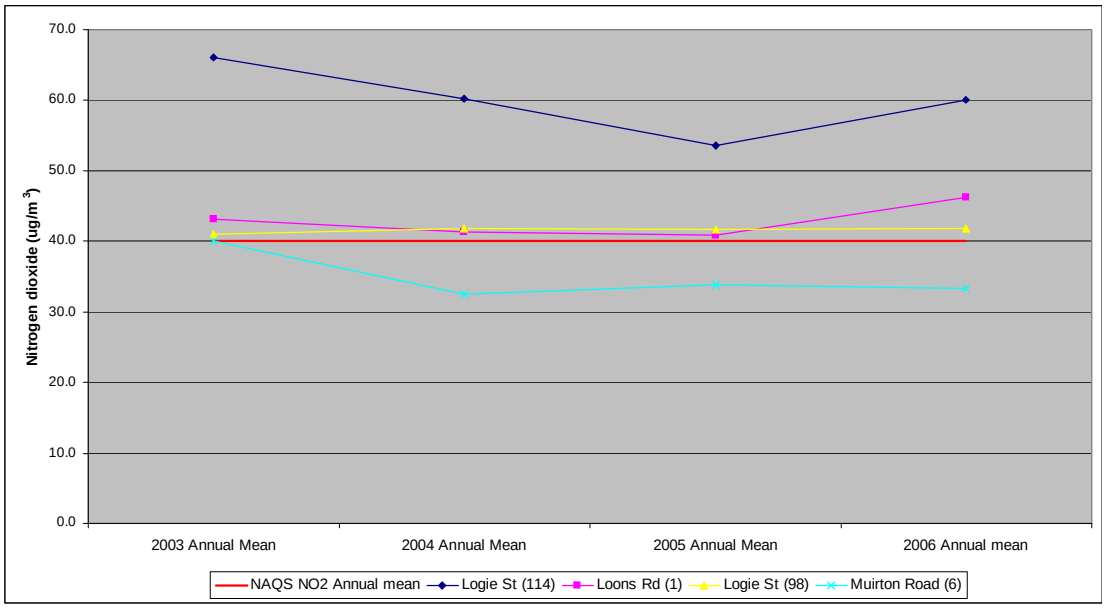
Figure 3.2(25) - Nitrogen Dioxide tubes in and around Logie Street



There are four NO_2 diffusion tubes located around this junction (Logie Street 114, Logie Street 98, Loons Road 1 and Muirton Road 6) **(Figure 3.2(25))**. Only one of these tubes recorded a concentration of NO_2 that exceeds the 2005 objective, when bias corrected (Logie Street 114, 46.9µg/m^3). This tube is located at the façade of a building and is therefore directly representative of public exposure in this area. This area has been identified in previous assessments and is within the AQMA.

Figure 3.2(26) shows the changes in uncorrected NO_2 concentrations in diffusion tubes in this area over the past 4 years.

Figure 3.2(26) - Annual Measured NO_2 Concentrations in Logie Street

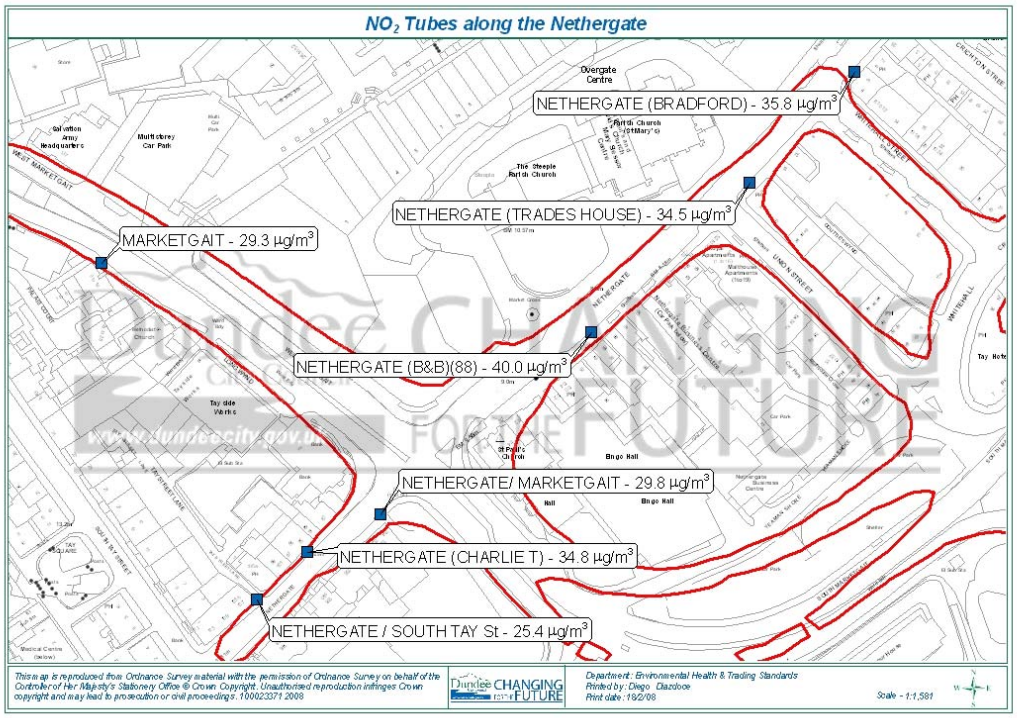


The tubes south of the junction showed a marked increase in 2006, it is too soon to say if this will be a continuing trend. A change in the timing of the traffic lights may have resulted in traffic wanting to turn right from Logie St. to Loons Rd being held back for longer in the vicinity of these tubes.

3.2.4.6 Nethergate

The Nethergate/Marketgait junction is a busy controlled junction and the Nethergate is part of the main bus corridor running through the city centre. There is residential exposure from first floor at various locations along the length of the Nethergate.

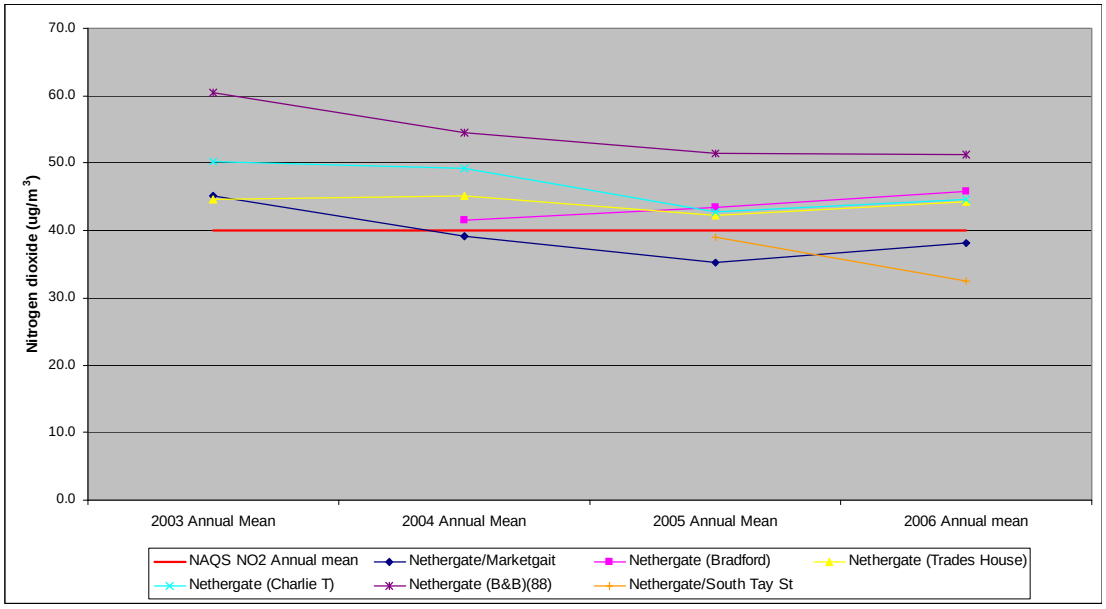
Figure 3.2(27) - Nitrogen Dioxide tubes along the Nethergate



The highest concentration of NO_2 (40 µg/m^3) was measured at the Nethergate (B & B)(88) tube **(Figure 3.2(27))**; only this result was greater than 36 µg/m^3. This tube is located adjacent to two main city centre bus stops. The 0.78 bias corrected tubes west of the junction are below 36µg/m^3. This area has been identified in previous assessments and is within the AQMA.

Figure 3.2(28) shows the changes in uncorrected NO_2 concentrations in diffusion tubes in this area over the past 4 years.

Figure 3.2(28) - Annual Measured NO_2 Concentrations at Diffusion Tubes in Nethergate

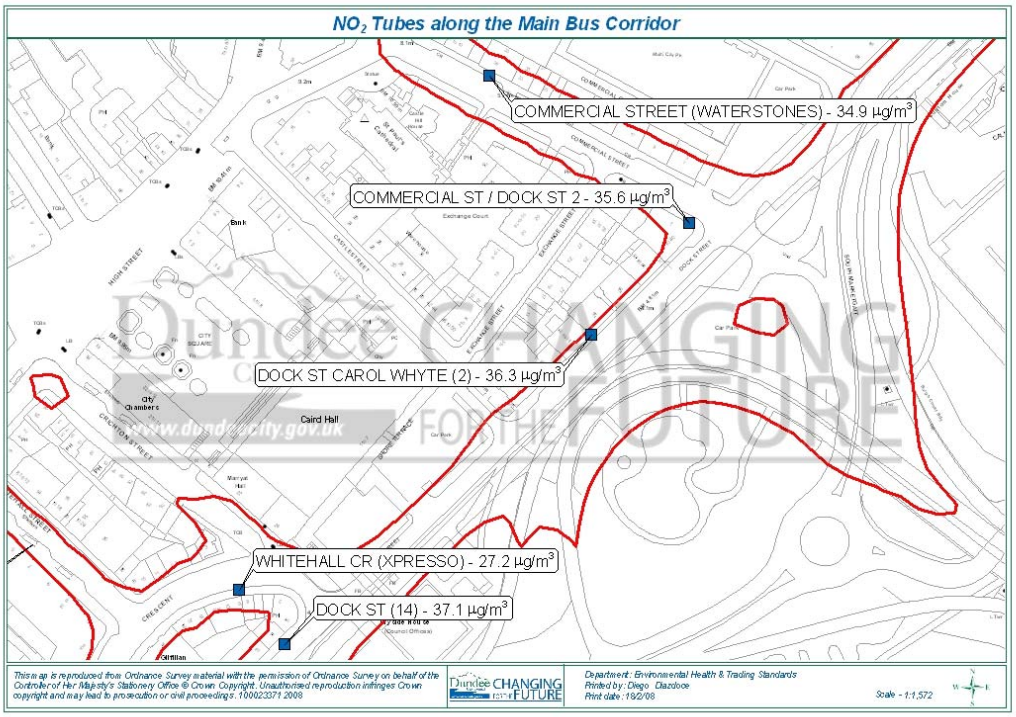


The Nethergate tubes generally show a decline since 2003 which was a higher than usual pollution year but appear to increase again in 2006.

3.2.4.7 Main City Centre Bus Corridor

As well as the Seagate, St Andrews Street, Nethergate, Union Street and Whitehall Street, there are other potential exceedences of the 2005 objective for nitrogen dioxide predicted along the main city centre bus corridor, in Dock Street (36.3 and 37.1 µg/m^3).

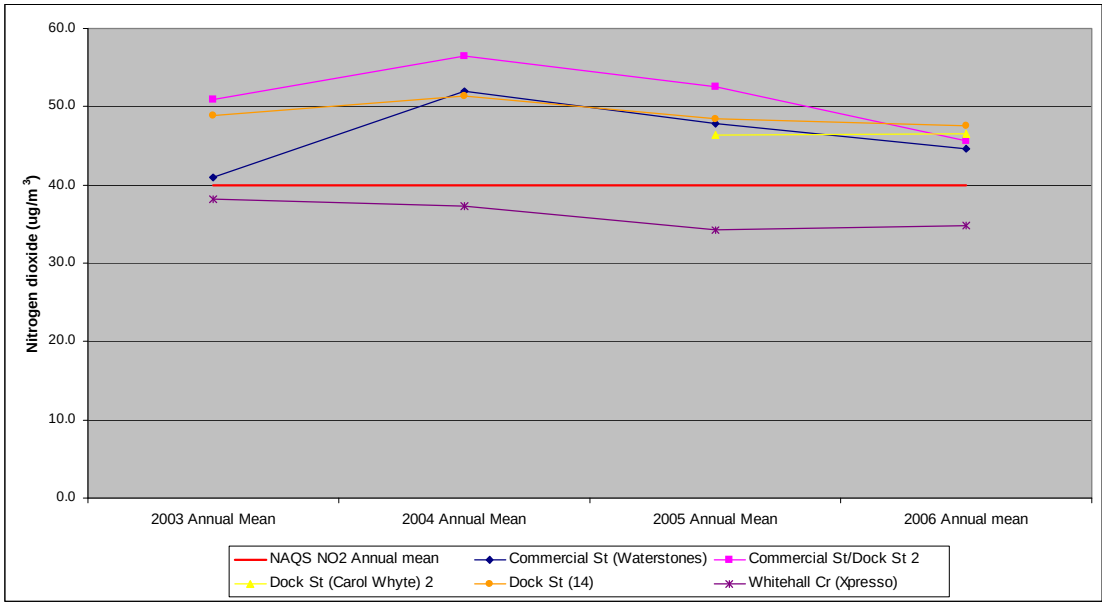
Figure 3.2(29) - Other Nitrogen Dioxide tubes along the Main Bus Corridor



This area **(Figure 3.2(29))** has been identified in previous assessments and is within the AQMA. There were major road works along the length of Dock Street associated with the strengthening of the rail tunnel that runs beneath. This altered the route taken by many bus services in the city centre and hence the concentration of NO_2 measured at these locations. The strengthening of the rail tunnel reduced bus traffic in the area which may have caused the slight decrease in NO_2 levels between 2005 and 2006.

Figure 3.2(30) shows the changes in uncorrected NO_2 concentrations in diffusion tubes in this area over the past 4 years.

Figure 3.2(30) - Annual Measured NO_2 Concentrations along the Main Bus Corridor

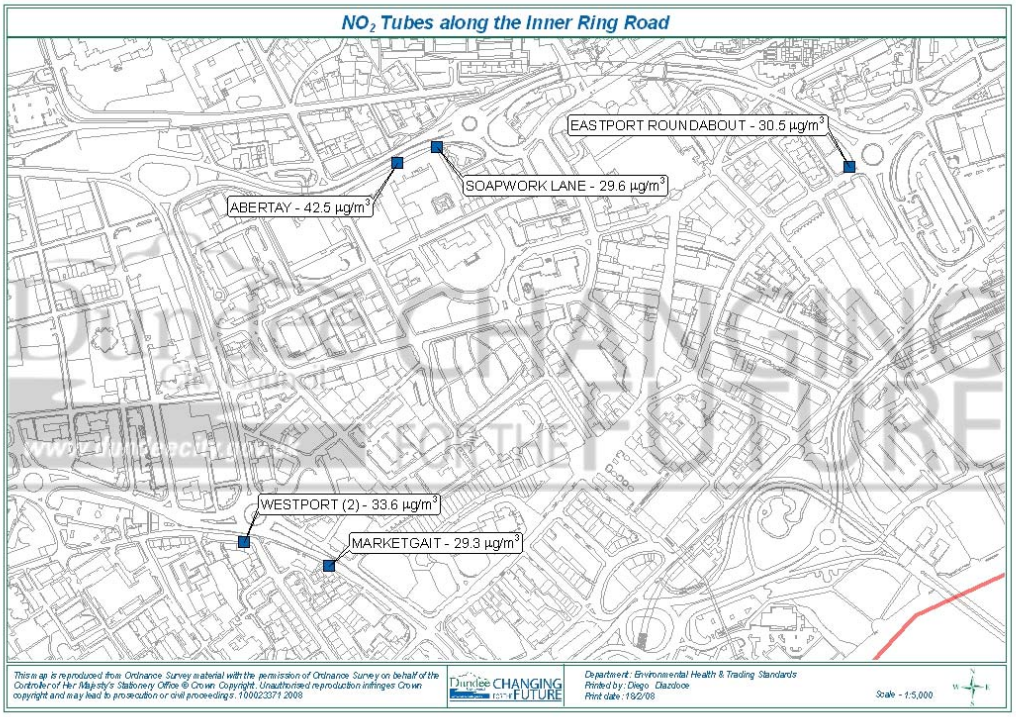


These tubes generally show a slight decline since 2003 which was a higher than usual pollution year.

3.2.4.8 Inner Ring Road

The inner ring road surrounds the city centre, and is comprised of the West, East, South and North Marketgait. Part of the South Marketgait includes the trunk road taking traffic to and from the Tay Road Bridge. There is relevant exposure at ground floor and first floor residences at various locations along the inner ring road.

Figure 3.2(31) - Nitrogen Dioxide tubes along the Inner Ring Road

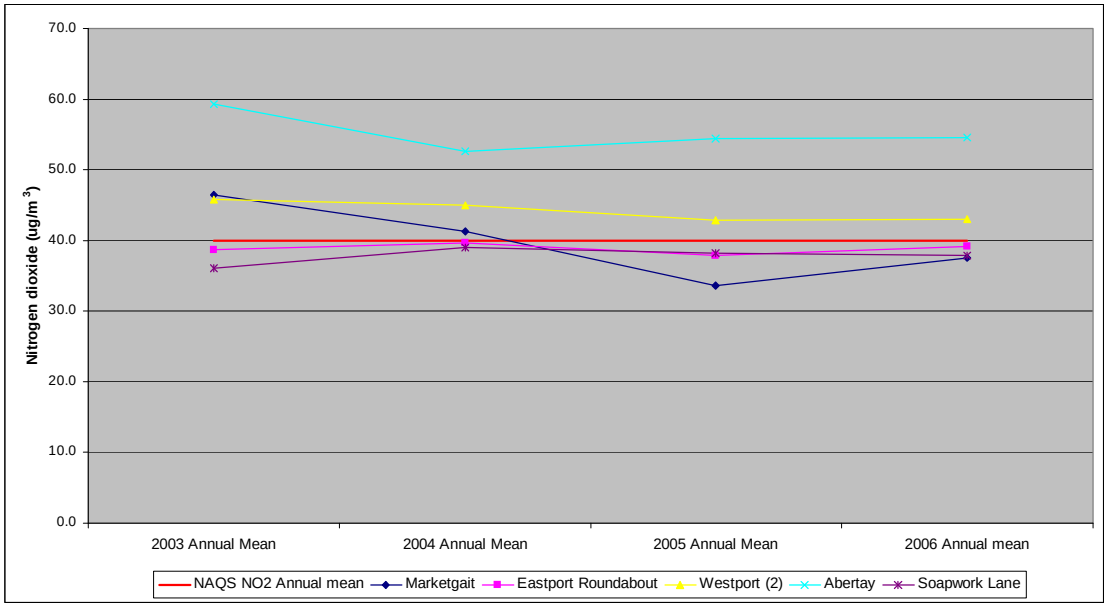


There were five tubes located around the inner ring road (Abertay, Marketgait, Westport 2, Soapwork Lane and Eastport Roundabout) in 2006 **(Figure 3.2(31))**. The only location that showed an exceedence of the 2006 objective was Abertay (42.5 µg/m^3). Fortunately, this is the only one of the five locations where there is currently no relevant public exposure. Abertay is a long-term site and its results are useful in identifying trends in NO_2 levels. All the Inner Ring tubes increased from 2005 to 2006 except for Soapwork Lane which decreased slightly.

The plans to expand City Centre shopping facilities will necessitate the signalisation of the Dudhope roundabout which is located on the inner ring road where the West Marketgait meets the North Marketgait. This may have an effect on the NO_2 concentrations recorded elsewhere on the inner ring road and the surrounding road network.

Figure 3.2(32) shows the changes in uncorrected NO_2 concentrations in diffusion tubes in this area over the past 4 years.

Figure 3.2(32) - Annual Measured NO_2 Concentrations on the Inner Ring Road

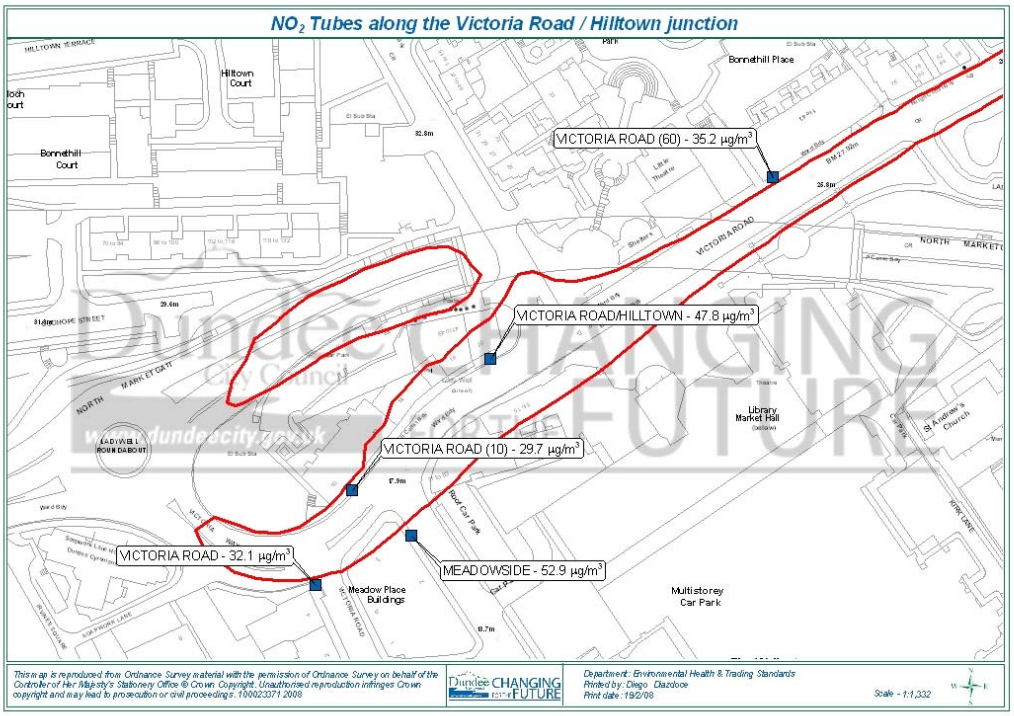


The Inner Ring tubes generally show a slight decline since 2003 which was a higher than usual pollution year. The Marketgait tube levels have increased in 2006 as traffic levels returned to normal after road works in 2005 prevented traffic going past the tube for much of the year.

3.2.4.9 Victoria Road

There are several controlled junctions on this part of the northeast arterial route for the city, which is also a major bus route. The road has a steep gradient that means vehicles passing through these junctions produce increased emissions. There is also a multi-storey car park nearby that may increase the volume of cold-start emissions passing through this area. The area is also a street canyon which can further trap pollutants, and there is residential exposure at the roadside from ground level upwards.

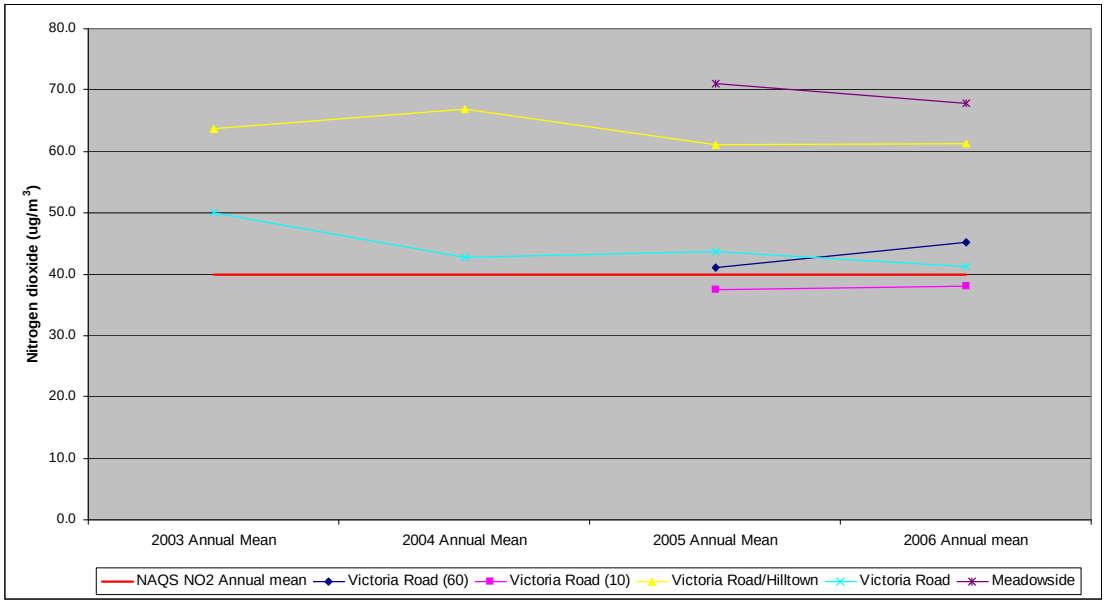
Figure 3.2(33) - Nitrogen Dioxide tubes around the Victoria Road / Hilltown Junction



There were five tubes situated in the vicinity of this junction in 2006 (Victoria Road, Victoria Road/Hilltown, Victoria Road(10), Victoria Road(60), and Meadowside) **(Figure 3.2(33))**. The only locations that showed an exceedence of the 2005 objective were Victoria Road/Hilltown (47.8 µg/m^3) and Meadowside (52.9 µg/m^3). Additional tubes were deployed to help determine the geographic extent of this area of exceedence. This has indicated that the area may not extend as far to the west of the junction as predicted but should extend further down Meadowside.

Figure 3.2(34) shows the changes in uncorrected NO_2 concentrations in diffusion tubes in this area over the past 4 years.

Figure 3.2(34) - Annual Measured NO_2 Concentrations in and around Victoria Road

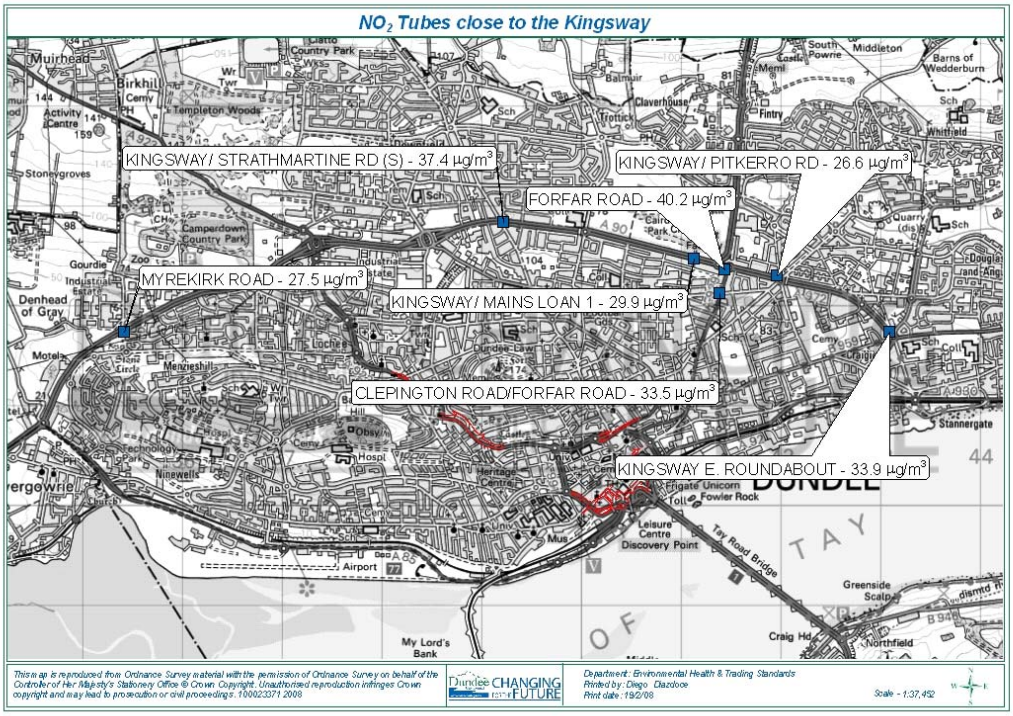


The long-term Victoria Road / Hilltown Junction tubes show a slight decline since 2003 which was a higher than usual pollution year. NO_2 levels on the main bus corridor through this junction show the highest results overall.

3.2.4.10 Kingsway

The Kingsway is an outer ring road that by-passes the centre of Dundee and is part of the trunk road network carrying traffic to and from Aberdeen, Arbroath and Perth.

Figure 3.2(35) - Nitrogen Dioxide Tubes close to the Kingsway

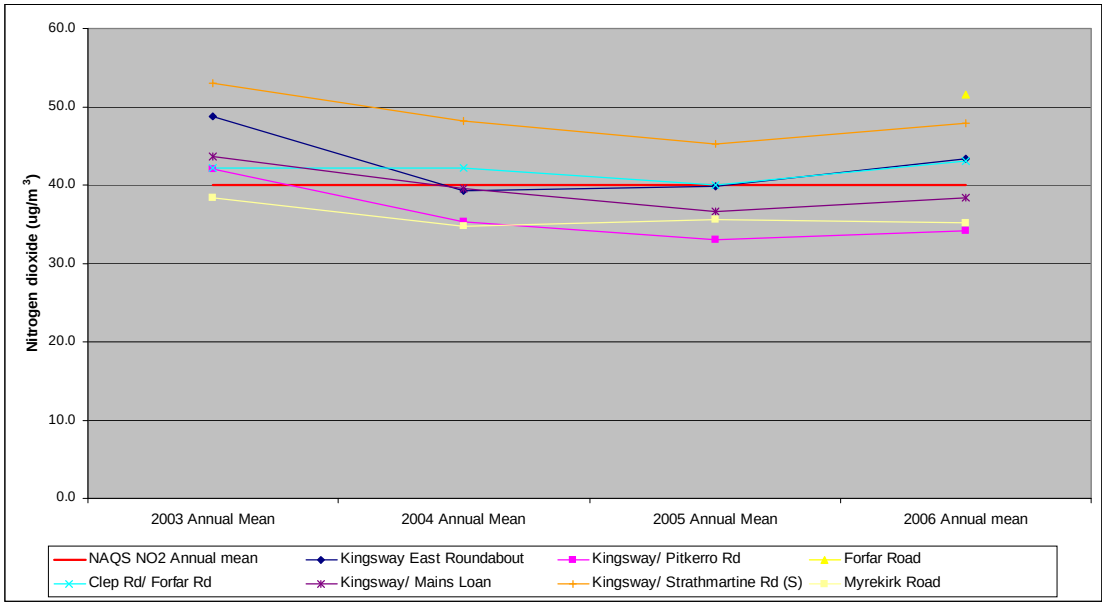


There were seven tubes situated close to Kingsway in 2006 **(Figure 3.2(25))**. The only tube locations that showed potential exceedences of the objective were at the Kingsway/ Strathmartine Road (37.4 µg/m^3) and Forfar Road (40.2 µg/m^3). The predicted level at the nearest residential building façade is 28.0 and 38.2 µg/m^3 respectively. This identifies Forfar Road as a new area of concern where it meets the Kingsway. The Kingsway is an open location and pollutants disperse with increasing distance from the roadside.

There are plans to signalise the roundabout at the junction of the Kingsway and the Forfar Road (trunk road A90(T)). This may have an impact on the NO_2 concentrations recorded in the vicinity of this junction and the surrounding road network. The signalisation of this major junction may have an impact on traffic management along the Kingsway.

Figure 3.2(36) shows the changes in uncorrected NO_2 concentrations in diffusion tubes in this area over the past 4 years.

Figure 3.2(36) - Annual Measured NO_2 Concentrations close to the Kingsway.

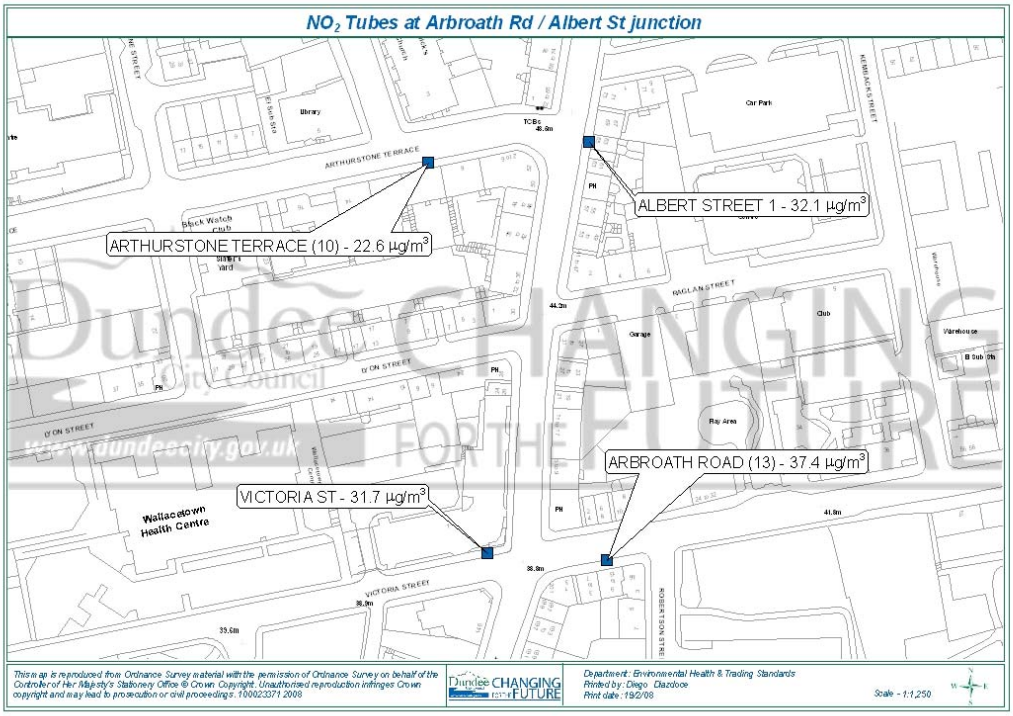


The tubes close to the Kingsway generally show a slight decline since 2003 which was a higher than usual pollution year but appear to increase again in 2006.

3.2.4.11 Arbroath Road / Albert Street Junction

The Arbroath Road / Albert Street Junction is a busy junction on the north east arterial route with residential exposure from ground floor upwards.

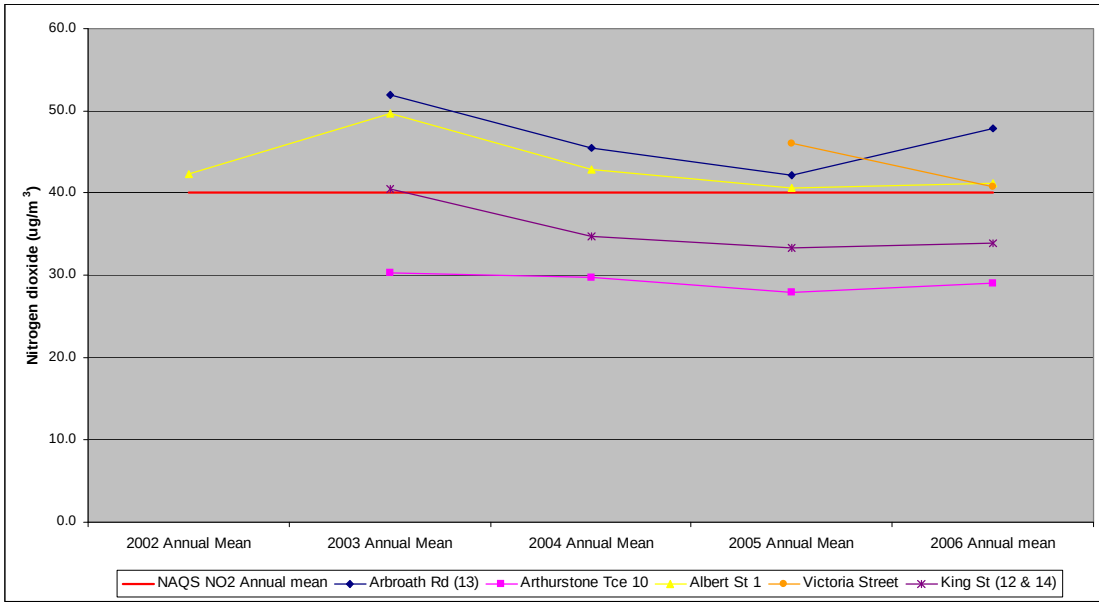
Figure 3.2(37) - Nitrogen Dioxide tubes close to the Arbroath Rd / Albert St Junction



This area **(Figure 3.2(37))** had been assessed previously and ruled out as an area of exceedence in the detailed assessment, but the increase in Arbroath Road (13) tube levels to 37.4 (µg/m^3) identifies this area once again as a potential area of exceedence.

Figure 3.2(38) shows the changes in uncorrected NO_2 concentrations in diffusion tubes in this area over the past 4 years.

Figure 3.2(38) - Annual Measured NO_2 Concentrations at Diffusion Tubes close to the Arbroath Rd / Albert St Junction



The tubes close to the Arbroath Road / Albert Street junction generally show a slight decline since 2003 which was a higher than usual pollution year but Arbroath Road (13) appears to increase dramatically in 2006. This increase is thought to be partly due to traffic management changes in the area which opened up Victoria Street to westbound traffic making this an alternative route into the city centre from the east.

3.2.5 Conclusion

At the majority of the NO_2 tube locations the measured NO_2 concentrations were observed to have increased since 2005. Increased concentrations were also recorded at the long term continuous monitoring site in Union Street. The previous decline in concentrations measured at this site appears to have levelled off and may even be reversing.

There continue to be areas of exceedences and hence the need for the AQMA and development of an Action Plan. Furthermore, two new areas of potential exceedence, have been identified at the Kingsway/Forfar Road and Arbroath Road/Albert Street Junctions.

3.3 SMALL PARTICLES (PM_{10})

OBJECTIVES :

40 micrograms per cubic metre or less, when expressed as an annual mean, to be achieved by 31st December 2004.

50 micrograms per cubic metre or less, when expressed as a 24-hour mean, not to be exceeded more than 35 times a year to be achieved by 31st December 2004.

18 micrograms per cubic metre or less, when expressed as an annual mean to be achieved by 31st December 2010.

50 micrograms per cubic metre or less, when expressed as a 24-hour mean, not to be exceeded more than 7 times a year to be achieved by 31st December 2010.

3.3.1 Measurement Methods – Partisol, TEOM and OSIRIS

There is a wide variety of different sampling and detection methodologies available for ambient particulate measurements. Dundee City Council employ three types of measurement methods:

- The Partisol sampler is the EU reference method for measuring particulates. It is a gravimetric sampler that collects daily samples onto a filter for subsequent weighing to determine the PM_{10} concentration.

- The tapered element oscillating microbalance (TEOM) system determines particulate concentrations by continuously weighing particles that are deposited on a filter.

- The OSIRIS uses a nephalometer which sizes and counts individual particles as they pass through a laser beam.

3.3.2 Instrumentation

Each of the three TEOM PM_{10} monitoring sites is equipped with an Rupprecht & Patashnick (R&P) TEOM series 1400ab Ambient Particulate Monitor. The five nephalometer sites are equipped with OSIRIS particulate monitors supplied by Turnkey Instruments. The Partisol is an R&P 2025 sequential gravimetric sampler.

3.3.3 Data Quality Requirements

Each TEOM unit is calibrated under software support by using the single pre-weighed filter contained in the Mass Calibration Verification Kit. This verification is undertaken by the equipment suppliers on an annual basis as part of the maintenance contract. Each TEOM is audited twice yearly by AEAEE.

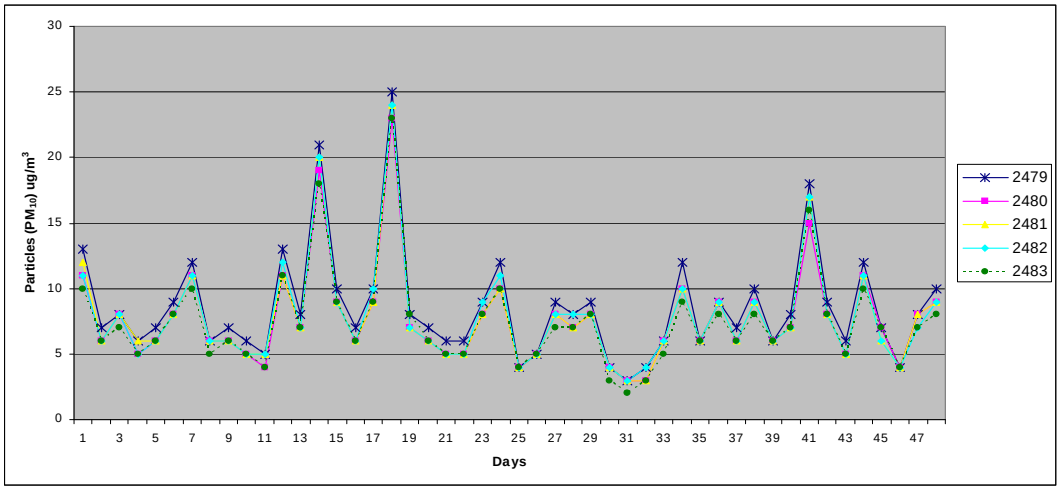
The Partisol is serviced and maintained in accordance with manufacturer's instructions and is audited twice yearly by AEAEE. The filter cassette is changed fortnightly by Dundee Scientific Services, who also condition and weigh the filters.

The OSIRIS Units are serviced and calibrated annually, and receive quarterly filter change and flow checks as per the manufacturer's instruction.

3.3.4 OSIRIS Intercomparison Study 2005

The OSIRIS monitors are considered suitable for screening studies but are not recommended for Detailed Assessments. Dundee City Council has five OSIRIS monitors which are serviced and calibrated annually by the manufacturer. In order to assess the instruments' measurement precision, an intercomparison study was carried out in 2005 after the 5 units had undergone their annual calibration and was reported in the USA (2006) (***Figure 3.3(1)***). It was found that the OSIRIS monitor's PM_{10} measurements were closely correlated with each other. The period averages recorded by each monitor differed by only +/- 7% to that recorded by the designated local 'master', which is collocated with the TEOM in Union Street.
The results of this study showed that it would be reasonable to apply the correction factor derived from the 'master' OSIRIS/TEOM intercomparison (see **Section 3.3.5**) to all the OSIRISs

Figure 3.3(1) - OSIRIS Intercomparison Study 2005

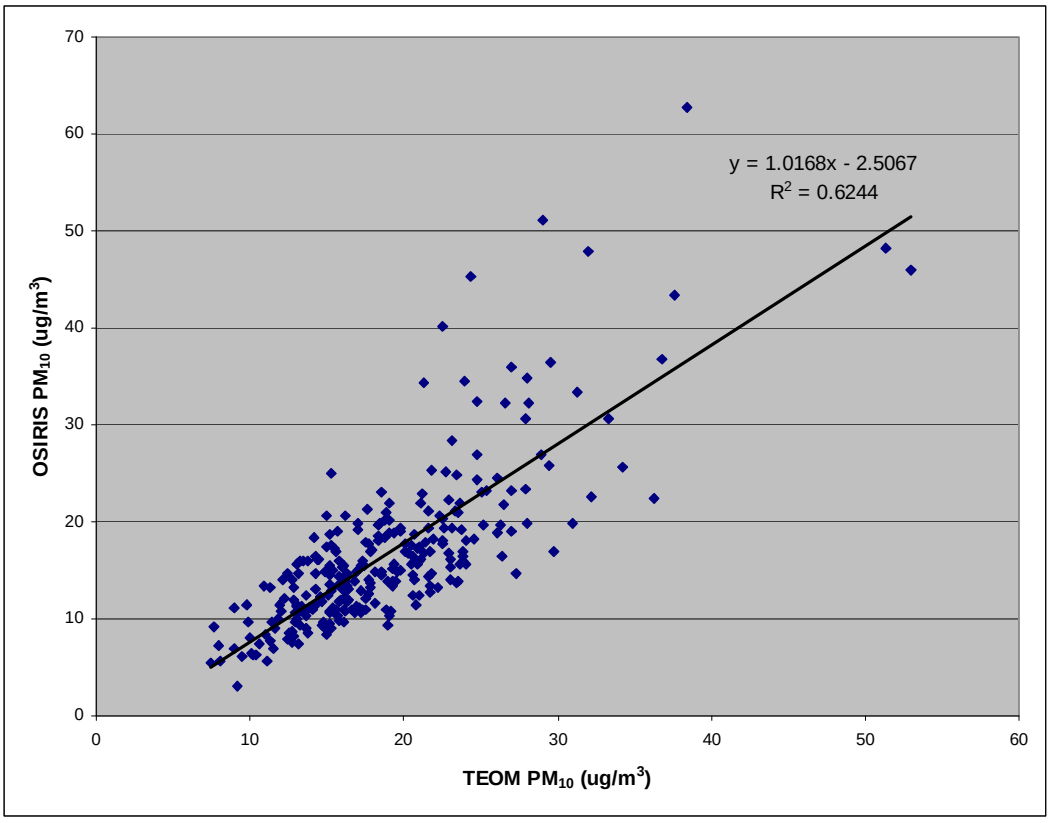


3.3.5 OSIRIS / TEOM Intercomparison Study Union Street in 2006

To try and improve the accuracy of the OSIRIS results and provide a means of estimating equivalent gravimetric concentrations, the 'master' OSIRIS was co-located with the TEOM in Union Street. Both monitors have heated inlets which result in losses of volatile particulate components. The study compared 15min, hourly and 24 hour averages, for the OSIRIS 'master' and the ratified Union Street TEOM results and established that the daily averages showed the best correlation. See ***Figure 3.3(2)*** for the comparison of the daily

concentrations. Comparing equivalent daily averages in 2006 for each of the monitors found that the OSIRIS was under-reading compared to the TEOM, based on a data capture of 77%. This meant the OSIRIS would need to be **factored by 1.13** to be equivalent to the TEOM. Hence the annual mean OSIRIS results presented in this report have been factored by 1.13 prior to gravimetric correction factors being applied.

Figure 3.3(2) - Comparison of daily concentrations of PM_{10} measured by co-located OSIRIS and TEOM Monitors during 2006 (77%data capture)



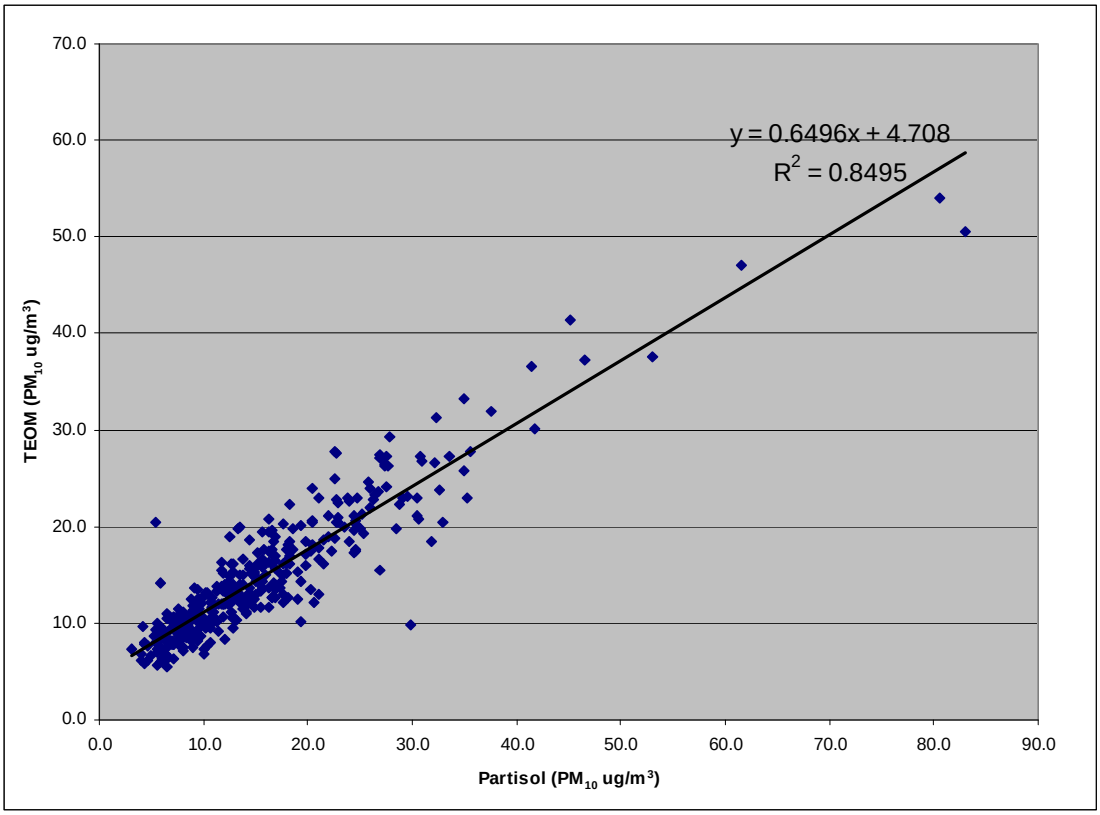
3.3.6 Partisol / TEOM Intercomparison Study Broughty Ferry Road in 2006

Due to the need to eliminate the effect of changing humidity on the mass measurement of particulates, TEOMs must maintain the sample filter at an elevated temperature. This has led to reported differences in concentrations of particulates between the TEOM and the European reference sampler (e.g. Partisol) that is largely attributed to the loss of volatile species such as ammonium nitrate. As an interim measure, a default 'scaling factor' (also known as correction factor) of 1.3 is currently applied to all nationally reported TEOM PM_{10} data in the UK as recommended by the EC Working Group on Particulate Matter. It was considered that this factor may be too high for Scotland and local authorities were encouraged to apply for funding to carry out their own studies and determine a local gravimetric correction factor. Dundee City Council was successful in obtaining funding for such a study and

co-located a Partisol 2025 sequential gravimetric sampler with the TEOM at Broughty Ferry Road. The results of this study are presented below.

The study compared daily average results from Partisol and the ratified Broughty Ferry Road TEOM results for a 12 month period (22nd June 2006 to 30th June 2007). Data capture during the period was 97.9%. Comparison of the equivalent daily averages (see **Figure 3.3(3)**) from both monitors showed good correlation. Comparison of the period means for the 12 months studied showed that the TEOM was under-reading compared to the Partisol and therefore it would be more appropriate to factor TEOM results by **1.05** (than 1.3) in Dundee.

Figure 3.3(3) - Comparison of daily concentrations of PM_{10} measured by co-located Partisol and TEOM Monitors during 2006 (97.9%data capture)



3.3.7 Summary of PM_{10} Annual Results for 2006

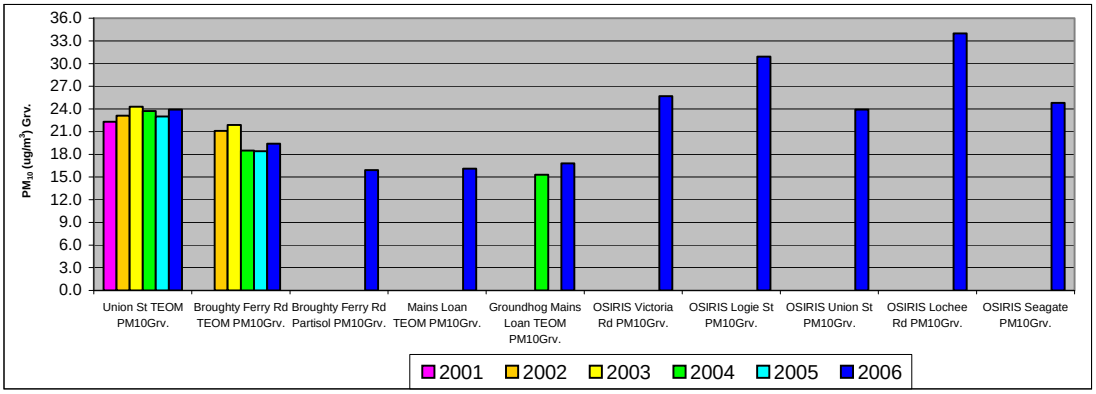
The PM_{10} results for the period 1 January to 31 December 2006 are shown in **Box 3.3(*i*)**. TEOM and OSIRIS results have been converted to gravimetric equivalent results where appropriate using the multiplier of 1.3 (in accordance with the technical guidance). The annual mean and data capture quoted are based on hourly data except for the Partisol which is daily. The annual means for sites with less than 75% data capture have been annualised using comparitve data from the nearest background AURN sites in Aberdeen and Edinburgh St. Leonards, which had 94.9% and 98.2% data capture respectively.

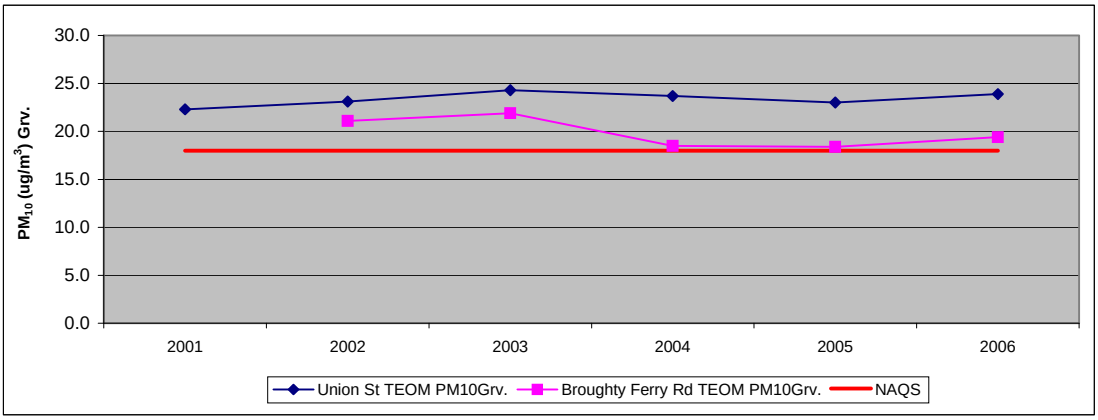
The Groundhog was located at the urban background site in Dundee during 2006 between 17 March and 17 September 2006.

Box 3.3(i) - Measured Annual Means (factored 1.3 grav.)

Measured Annual Mean PM_{10} (Grav. 1.3) (with data capture in %)

Year	Union St TEOM PM_{10}Grv.		Broughty Ferry Rd TEOM PM_{10}Grv.		**Broughty Ferry Rd Partisol PM_{10}Grv.**		Mains Loan TEOM PM_{10}Grv.		Groundhog Mains Loan TEOM PM_{10}Grv.		OSIRIS Victoria Rd PM_{10}Grv.		OSIRIS Logie St PM_{10}Grv.		OSIRIS Union St PM_{10}Grv.		OSIRIS Lochee Rd PM_{10}Grv.		OSIRIS Seagate PM_{10}Grv.	
	ug/m^3	%	ug/m^3	%	ug/m^3	%	ug/m^3	%	ug/m^3	%	ug/m^3	%	ug/m^3	%	ug/m^3	%	ug/m^3	%	ug/m^3	%
2001	22.3	95.6																		
2002	23.1	87.1	21.1	89.5																
2003	24.3	98.1	21.9	99.3																
2004	23.7	79.1	18.5	100					15.3	45.4										
2005	23.0	94.0	18.4	93.6																
2006	23.9	95.9	19.4	98.1	**15.9**	51.5	16.1	72.6	16.8	49.7	25.7	78.6	30.9	73.7	23.9	80.7	34.0	78.1	24.8	81.5





Recent guidance from the Scottish Executive[16] advised that, in light of the co-location study carried out by Edinburgh City Council, the annual mean TEOM results should also be multiplied by a factor of 1.14 and comparisons made between the two factored results and the annual mean objective. It should be noted that a local gravimetric correction factor of 1.05 has also been applied to these results. 2006 Annual mean results factored by all 3 gravimetric correction factors are shown in **Table 3.3a**

[16] Letter from Scottish Executive dated 6th April 2005, 'Local Air Quality Management: Update on Particles'

Table 3.3a - Summary of Annual Mean PM_{10} Results for 2001 to 2006 ($\mu g/m^3$) (Gravimetric)

Comparison of Measured Annual Mean PM_{10} when factored by Gravimetric equivalence factors **1.3**, 'Scottish' factor **1.14** and local factor **1.05**							
Monitors		**2001**	**2002**	**2003**	**2004**	**2005**	**2006**
Union St TEOM PM_{10}Grv.	1.3	**22.3**	**23.1**	**24.3**	**23.7**	**23.0**	**23.9**
	1.14	**19.6**	**20.3**	**21.3**	**20.7**	**20.2**	**21.0**
	1.05	18.0	**18.7**	**19.6**	**19.1**	**18.6**	**19.3**
Broughty Ferry Rd TEOM PM_{10}Grv.	1.3		**21.1**	**21.9**	**18.5**	18.4	**19.4**
	1.14		**18.5**	**19.2**	16.3	15.8	17.0
	1.05		17.0	17.7	15.0	14.6	15.6
Broughty Ferry Rd Partisol PM_{10}Grv.	1.3						**15.9**
	1.14						**15.9**
	1.05						**15.9**
Mains Loan TEOM PM_{10}Grv.	1.3						16.1
	1.14						14.1
	1.05						13.0
Groundhog Mains Loan TEOM PM_{10}Grv.	1.3				15.3		16.8
	1.14				13.4		14.7
	1.05				12.3		13.6
OSIRIS Victoria Rd PM_{10}Grv.	1.3						**25.7**
	1.14						**22.6**
	1.05						**20.8**
OSIRIS Logie St PM_{10}Grv.	1.3						**30.9**
	1.14						**27.1**
	1.05						**25.0**
OSIRIS Union St PM_{10}Grv.	1.3						**23.9**
	1.14						**21.0**
	1.05						**19.3**
OSIRIS Lochee Rd PM_{10}Grv.	1.3						**34.1**
	1.14						**29.9**
	1.05						**27.5**
OSIRIS Seagate PM_{10}Grv.	1.3						**24.8**
	1.14						**22.0**
	1.05						**20.0**

3.3.8 Summary of Annual Mean PM_{10} Results Predicted to 2010

In order to assess whether the measured annual means will achieve the NAQS(2010) objective it is necessary to predict the results forward. The methodology followed and the factors used for these calculations can be found in the update to the Technical Guidance in 2006.[17].

Table 3.3b, shows a summary of the predicted annual means for 2010 in each of the years for which monitoring results are available. The contribution from different PM_{10} sources does not remain constant between the current year and 2010. It is therefore not appropriate to apply a single correction

[17] Updated 2006 Guidance for Use of the Year Adjustment Factors for Background and Roadside Annual Mean Pollutant Concentrations'. - Yvonne Brown/Lucy Parkin 07/02/06

factor to measured data in the current year, to estimate concentrations in the future year. The measured data must first be divided into the separate source categories ('primary', 'secondary' and 'residual' previously 'coarse') and treated separately. Only the 'primary' component is important in terms of local emissions. The 'secondary' and 'residual' components can therefore be removed and added back in once future predictions have been performed.

Table 3.3b - Summary of Annual Mean PM_{10} Results Predicted to 2010 ($\mu g/m^3$) (Gravimetric)

Comparison of the Projected Annual Mean PM_{10} with the PM_{10} NAQS (2010) of 18ug/m^3 (factored by gravimetric equivalence factors 1.3, 'Scottish' factor 1.14 and local factor 1.05)							
Base year		2001	2002	2003	2004	2005	2006
Union St TEOM PM_{10}Grv.	1.3	20.0	20.9	22.2	22.0	21.4	22.4
	1.14	17.5	18.3	19.5	19.4	18.7	19.7
	1.05	16.2	16.9	17.9	17.9	17.2	18.2
Broughty Ferry Rd TEOM PM_{10}Grv.	1.3		19.2	20.2	17.4	17.1	18.2
	1.14		16.8	17.7	15.5	15.0	16.0
	1.05		15.5	16.3	14.3	13.8	14.8
Broughty Ferry Rd Partisol PM_{10}Grv.	1.3						15.0
	1.14						15.0
	1.05						15.0
Mains Loan TEOM PM_{10}Grv.	1.3						15.2
	1.14						13.4
	1.05						12.4
Groundhog Mains Loan TEOM PM_{10}Grv.	1.3				14.6		15.9
	1.14				13.0		13.9
	1.05				12.0		12.9
OSIRIS Victoria Rd PM_{10}Grv.	1.3						24.1
	1.14						21.2
	1.05						19.5
OSIRIS Logie St PM_{10}Grv.	1.3						28.9
	1.14						25.4
	1.05						23.4
OSIRIS Union St PM_{10}Grv.	1.3						22.4
	1.14						19.7
	1.05						18.2
OSIRIS Lochee Rd PM_{10}Grv.	1.3						31.8
	1.14						27.9
	1.05						25.8
OSIRIS Seagate PM_{10}Grv.	1.3						23.3
	1.14						20.5
	1.05						18.9

Figure 3.3(4) shows a comparison of the projected annual means in 2010 (base year 2006) for all sites and all gravimetric factors compared against the annual mean objective value of 18 $\mu g/m^3$.

Figure 3.3(4) - Comparison of 2006 Annual means projected to 2010 for All Sites (factored by 1.3, 1.14 and 1.05) with the NAQS Annual mean (2010)

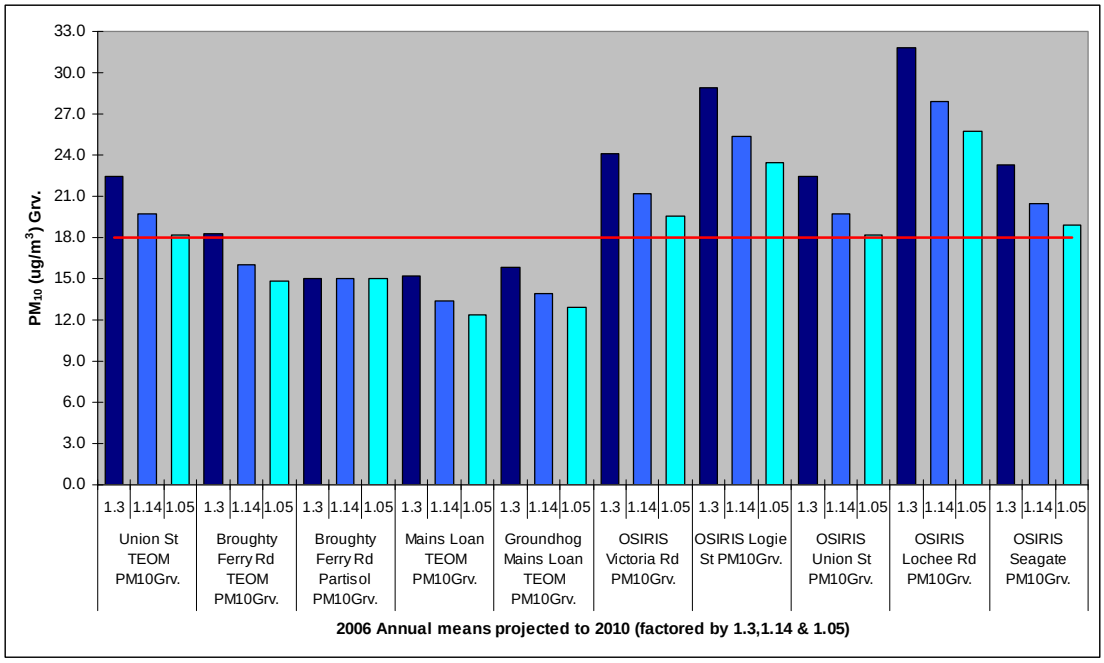
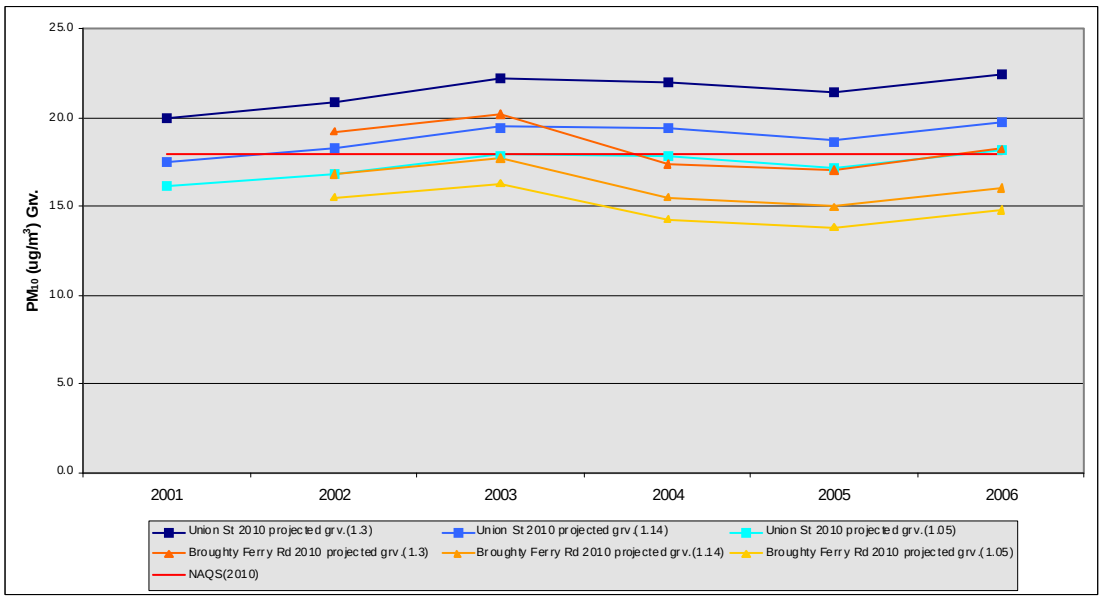


Figure 3.3(5) shows the changes in projected PM_{10} concentrations for 2010 at the long-term PM_{10} monitoring sites situated in Union Street and Broughty Ferry Road between 2001 and 2006 for all gravimetric factors.

Figure 3.3(5) - 2001 - 2006 Annual Mean PM_{10} projected to 2010 for Long-term Sites for all Gravimetric Factors

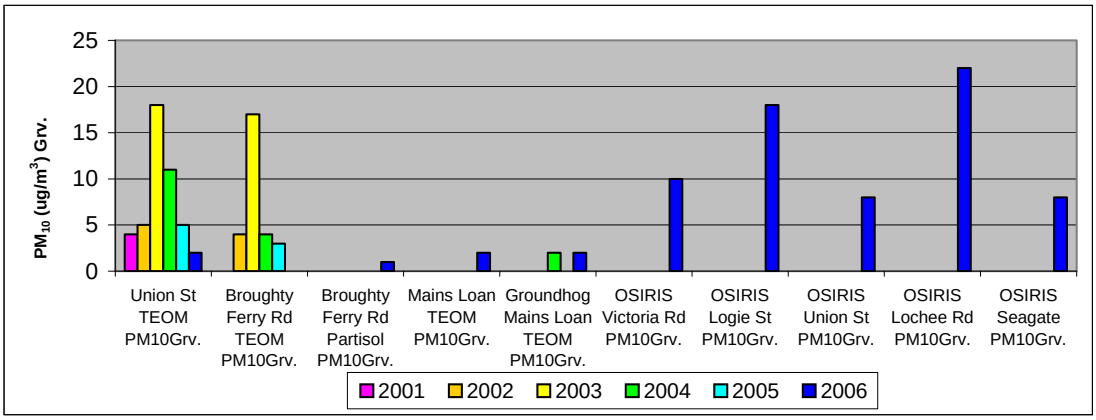


3.3.9 24-Hour Mean PM_{10} Concentrations in 2006

Box 3.3(ii) shows the number of exceedences of the 24-hour objective (50 µg/m³) for PM_{10} recorded at each of the automatic monitors during 2006 and previous years, where applicable. All the following results are based on the 1.3 gravimetric correction factor only.

Box 3.3(ii) - Number of exceedences of the 24-hour objective (50 µg/m^3) (no more than 35 allowed by 2004) (no more than 7 allowed by 2010)

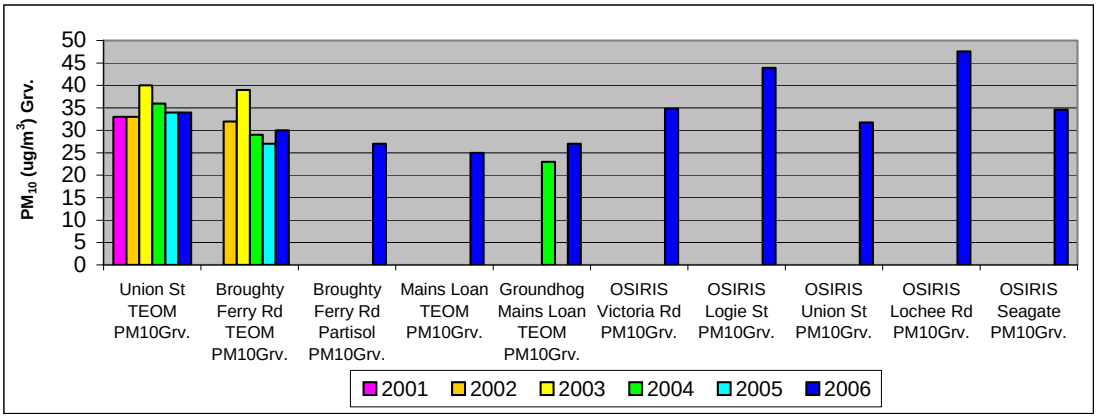
Number of exceedences of the 24hr mean (50ug/m^3)										
Year	Union St TEOM PM_{10}Grv.	Broughty Ferry Rd TEOM PM_{10}Grv.	**Broughty Ferry Rd Partisol PM_{10}Grv.**	Mains Loan TEOM PM_{10}Grv.	Groundhog Mains Loan TEOM PM_{10}Grv.	OSIRIS Victoria Rd PM_{10}Grv.	OSIRIS Logie St PM_{10}Grv.	OSIRIS Union St PM_{10}Grv.	OSIRIS Lochee Rd PM_{10}Grv.	OSIRIS Seagate PM_{10}Grv.
2001	4									
2002	5	4								
2003	**18**	**17**								
2004	**11**	4			2					
2005	5	3								
2006	2	0	**1**	2	2	**10**	**18**	**8**	**22**	**8**

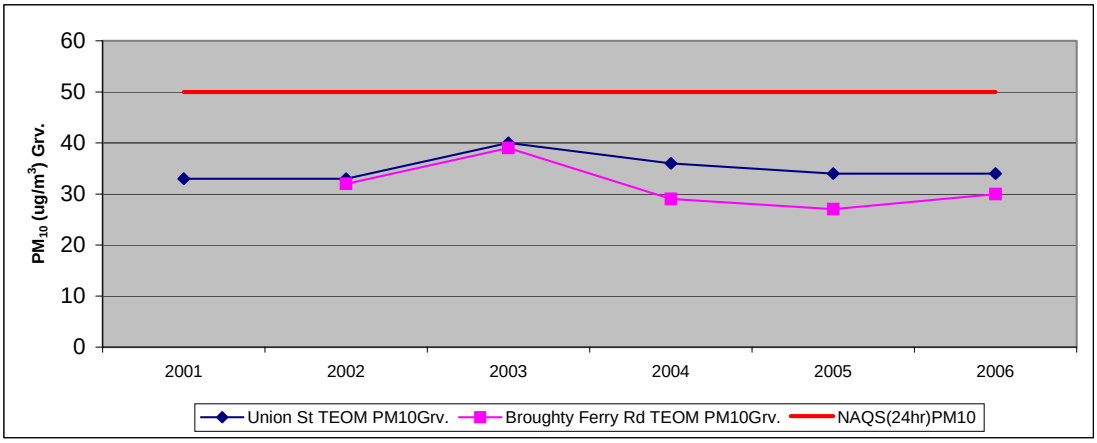


Where measured data capture is less than 90% the 24-hour objective concentration is expressed as a percentile value. This value aids comparison of monitoring data between different years and different monitors. The 90th and 98th percentile values are shown in **Box 3(iii) and 3(iv)** for comparison with the 2004 and 2010 24 hour objectives respectively. A percentile value greater than 50 µg/m^3 is indicative of there being an exceedence of the objective.

Box 3.3(iii) - 90th Percentile Values for all sites for available years

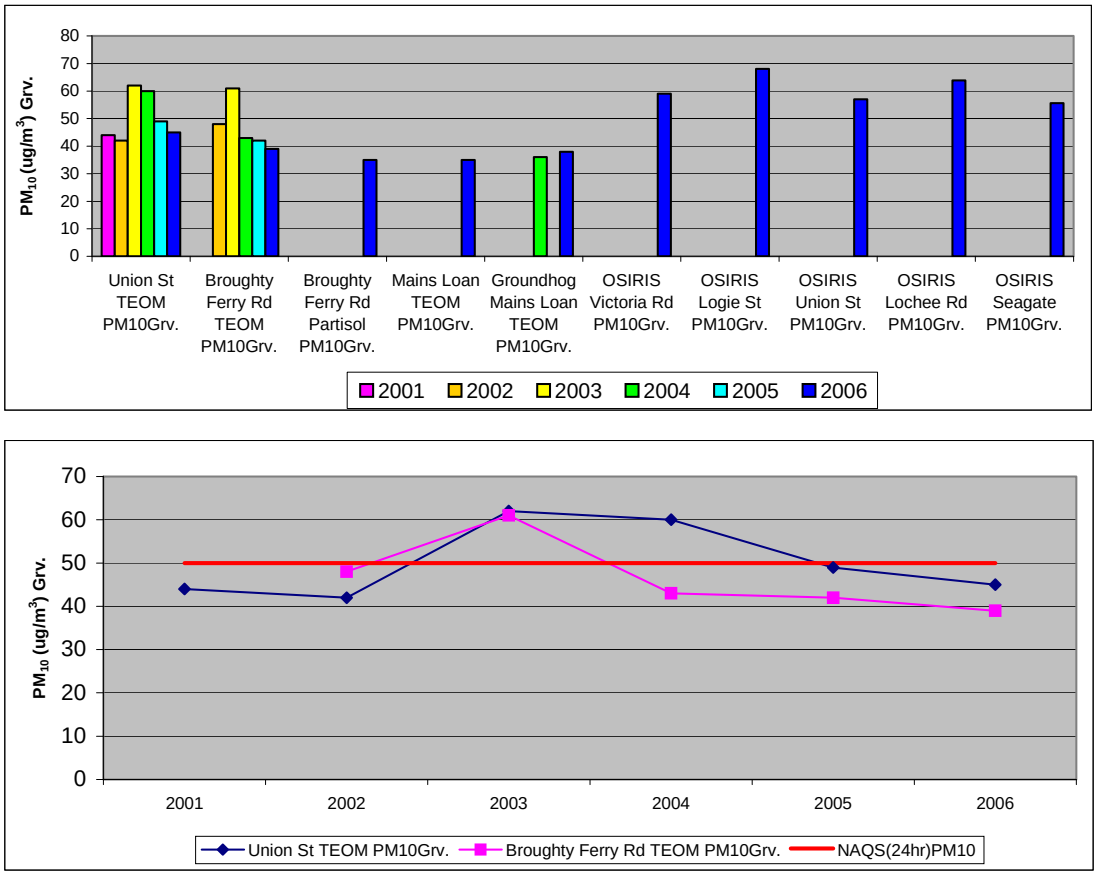
90th Percentile values										
Year	Union St TEOM PM_{10}Grv.	Broughty Ferry Rd TEOM PM_{10}Grv.	**Broughty Ferry Rd Partisol PM_{10}Grv.**	Mains Loan TEOM PM_{10}Grv.	Groundhog Mains Loan TEOM PM_{10}Grv.	OSIRIS Victoria Rd PM_{10}Grv.	OSIRIS Logie St PM_{10}Grv.	OSIRIS Union St PM_{10}Grv.	OSIRIS Lochee Rd PM_{10}Grv.	OSIRIS Seagate PM_{10}Grv.
2001	33									
2002	33	32								
2003	40	39								
2004	36	29			23					
2005	34	27								
2006	34	30	**27**	25	27	35	44	32	48	35





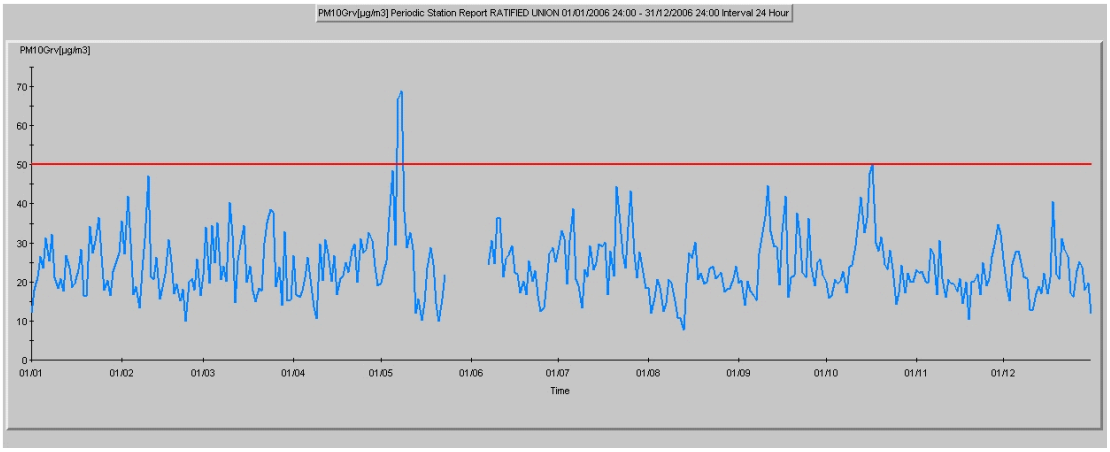
Box 3.3(iv) - 98th Percentile Values for all sites for available years

98th Percentile values										
Year	Union St TEOM PM_{10}Grv.	Broughty Ferry Rd TEOM PM_{10}Grv.	**Broughty Ferry Rd Partisol PM_{10}Grv.**	Mains Loan TEOM PM_{10}Grv.	Groundhog Mains Loan TEOM PM_{10}Grv.	OSIRIS Victoria Rd PM_{10}Grv.	OSIRIS Logie St PM_{10}Grv.	OSIRIS Union St PM_{10}Grv.	OSIRIS Lochee Rd PM_{10}Grv.	OSIRIS Seagate PM_{10}Grv.
2001	44									
2002	42	48								
2003	**62**	**61**								
2004	**60**	43			36					
2005	49	42								
2006	45	39	**35**	35	38	**59**	**68**	**57**	**64**	**56**



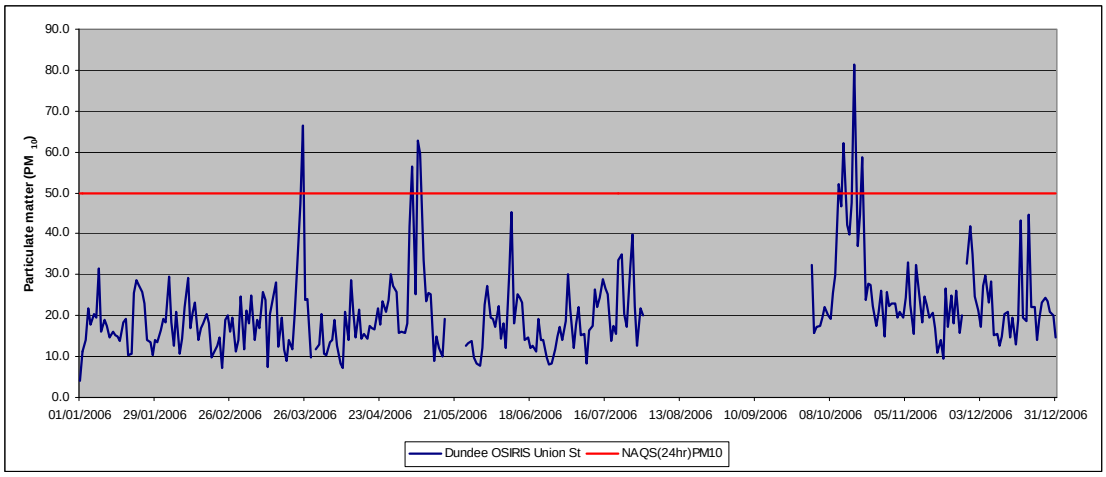
The following, **Figure 3.3(6) to 3.3(15)** show time series graphs of 24-hour average PM_{10} concentrations for each site, measured during 2006. Note the red line shows the 24-hour objective limit (50 µg/m^3).

Figure 3.3(6) - Time Series at Union Street of PM_{10} 24-Hour Mean in 2006 (in µg/m^3 grav.(1.3))



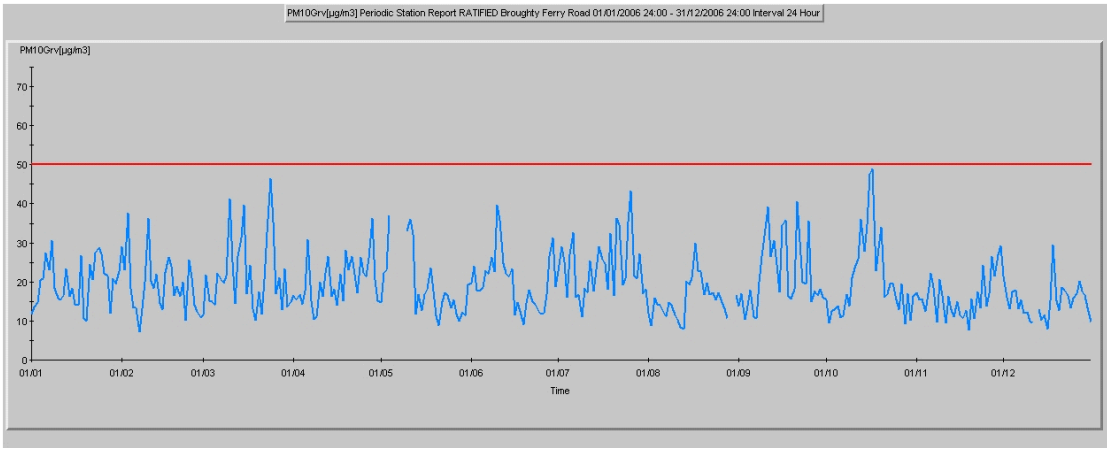
Data lost end of May - start of June 2006 due to faulty filter change.

Figure 3.3(7) - Time Series at Union Street OSIRIS of PM_{10} 24-Hour Mean in 2006 (in µg/m^3 grav.(1.3))



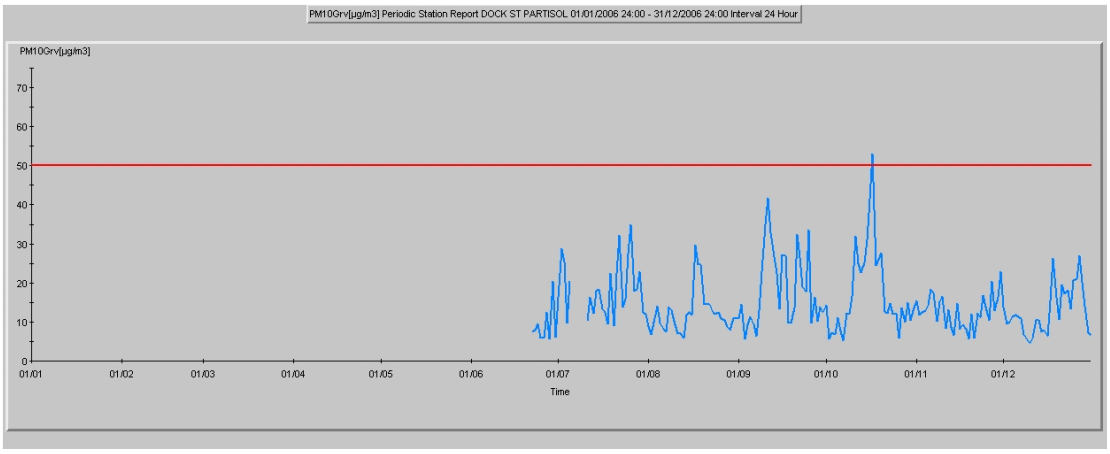
18th to 25th May and 31st August to 1st October 2006, data lost due to data collection software problem
1st - 31st August 2006, OSIRISs sent away for annual service and calibration.

Figure 3.3(8) - Time Series at Broughty Ferry Road of PM_{10} 24-Hour Mean in 2006 (in µg/m^3 grav.(1.3))



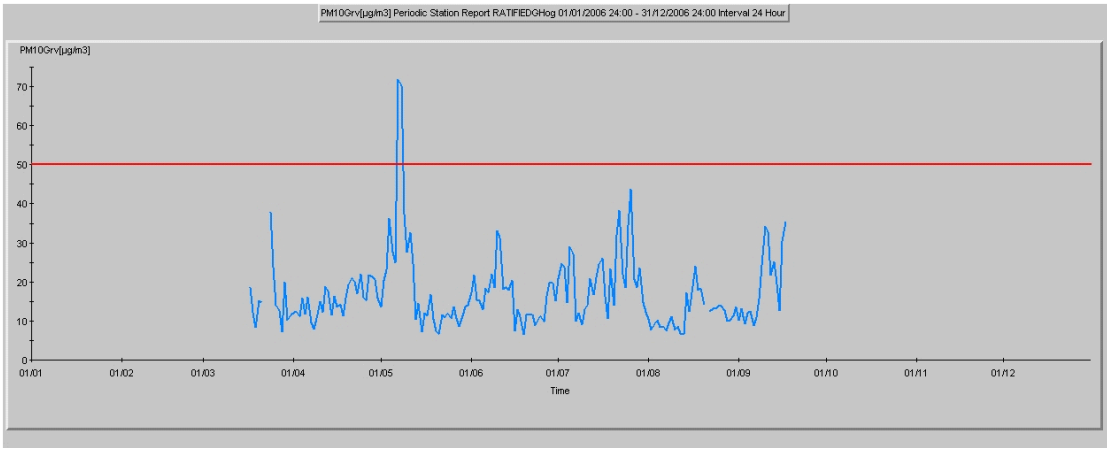
Data lost 5th to 9th May 2006 due to faulty filter change

Figure 3.3(9) - Time Series at Broughty Ferry Road Partisol of PM_{10} 24-Hour Mean in 2006 (in µg/m^3 grav.(1.3))



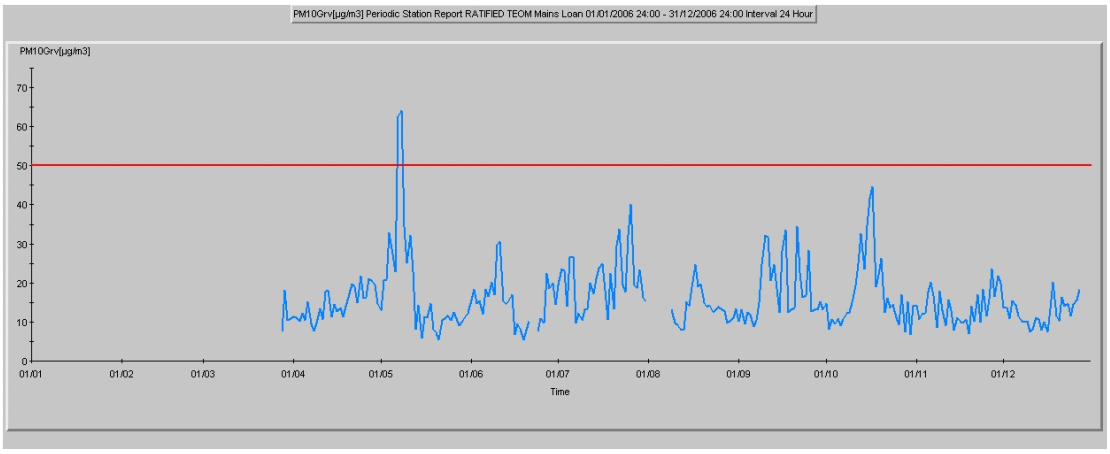
New monitor installed 22nd June 2006. 6th to 10th July 2006 data lost due to filter jam.

Figure 3.3(10) - Time Series at Groundhog Mains Loan of PM_{10} 24-Hour Mean in 2006 (in µg/m^3 grav.(1.3))



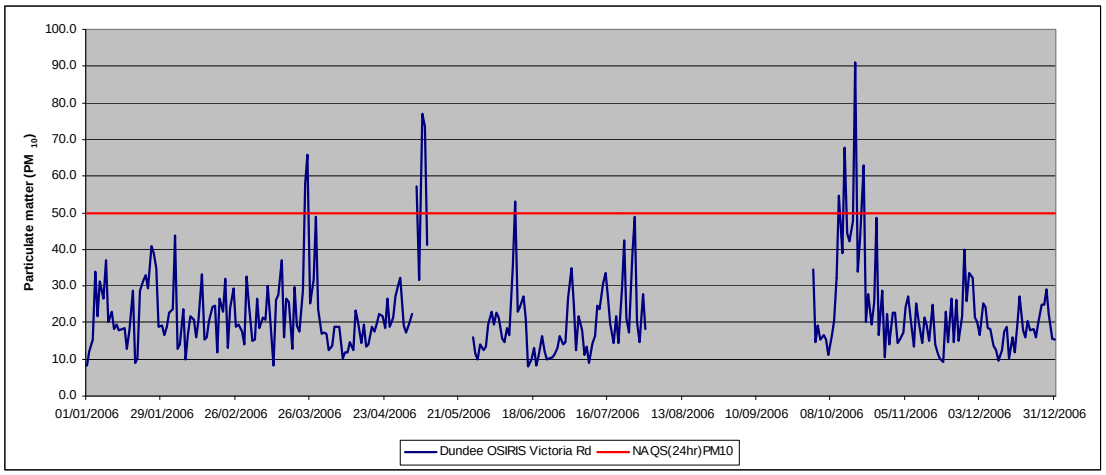
Groundhog is a mobile air quality monitor. It was present at Mains Loan from 17th March to 17th September 2006.

Figure 3.3(11) - Time Series at Mains Loan of PM_{10} 24-Hour Mean in 2006 (in µg/m^3 grav.(1.3))



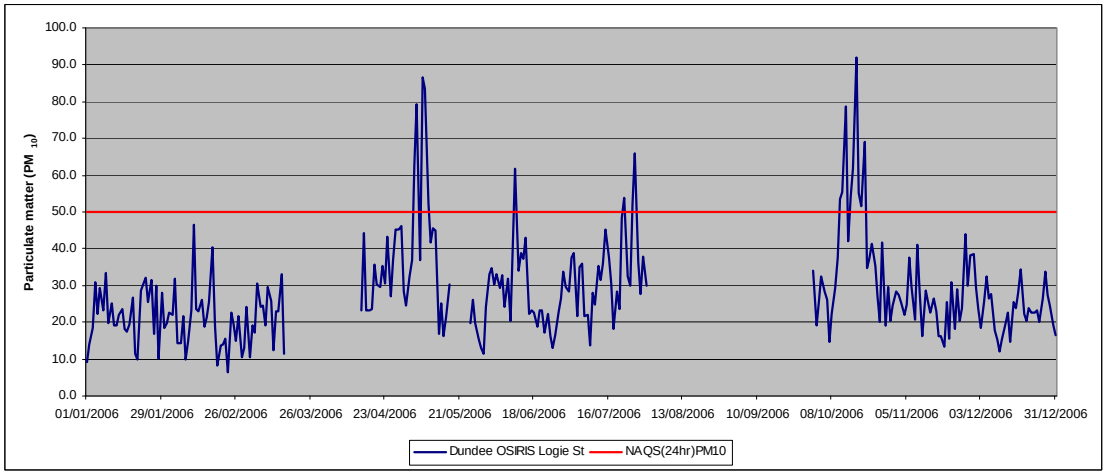
New monitor installed on 28th March 2006. Data lost 1st to 9th August 2006 due to data ratification

Figure 3.3(12) - Time Series at Victoria Road of PM_{10} 24-Hour Mean in 2006 (in µg/m^3 grav.(1.3))



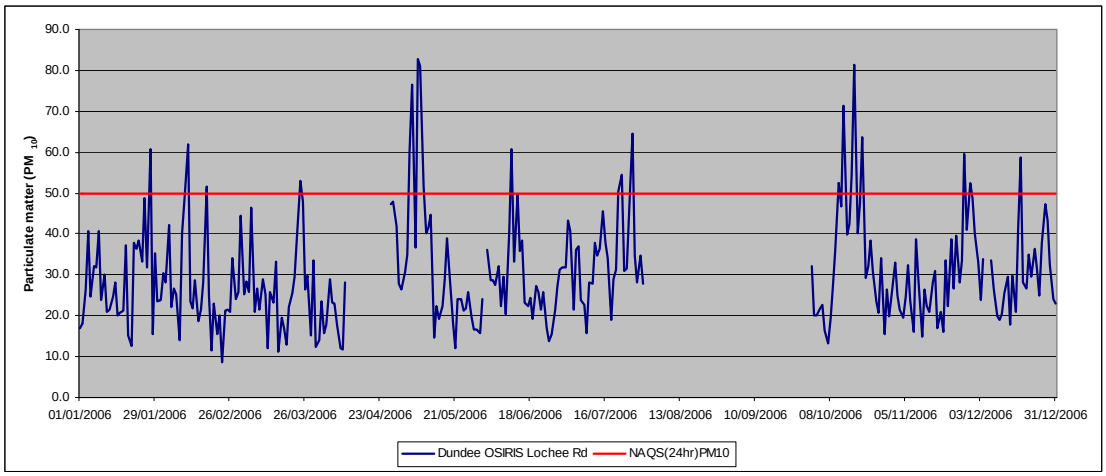
10th to 25th May 2006 Data lost due to power failure.
1st to 31st August 2006 OSIRISs sent away for annual service and calibration
31st August to 1st October 2006 Data lost due to data collection software problem

Figure 3.3(13) - Time Series at Logie Street of PM_{10} 24-Hour Mean in 2006 (in µg/m^3 grav.(1.3))



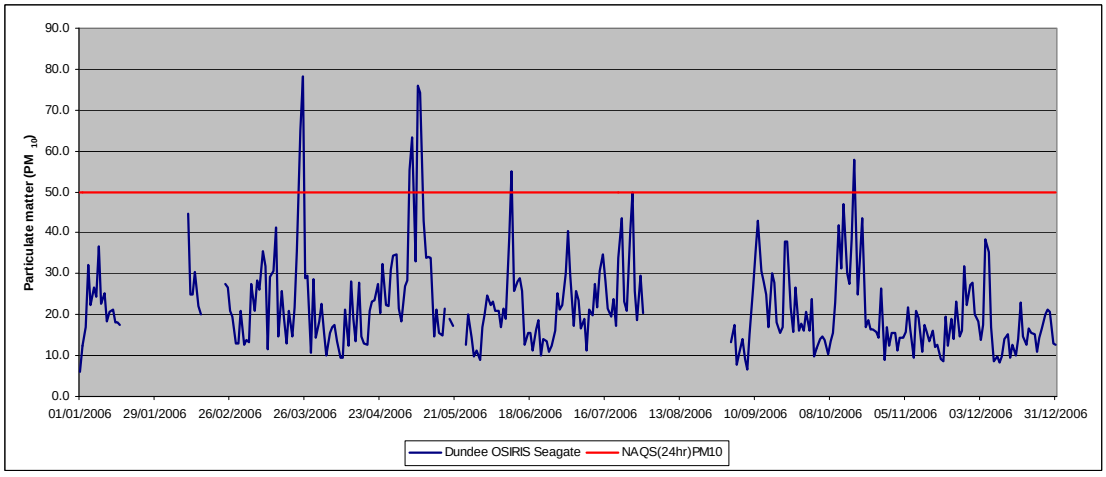
17th March to 13th April 2006 Data lost due to pump failure
1st to 31st August 2006 No data due to service and calibration
31st August to1st October 2006 Data lost due to data collection software problem

Figure 3.3(14) - Time Series at Lochee Road of PM_{10} 24-Hour Mean in 2006 (in µg/m^3 grav.(1.3))



11th April to 26th April 2006 Data lost due to pump failure.
1st to 31st August 2006 No data due to annual service and calibration.
31st August to 1st October 2006 Data lost due to data collection software failure.

Figure 3.3(15) - Time Series at Seagate of PM_{10} 24-Hour Mean in 2006 (in µg/m^3 grav.(1.3))

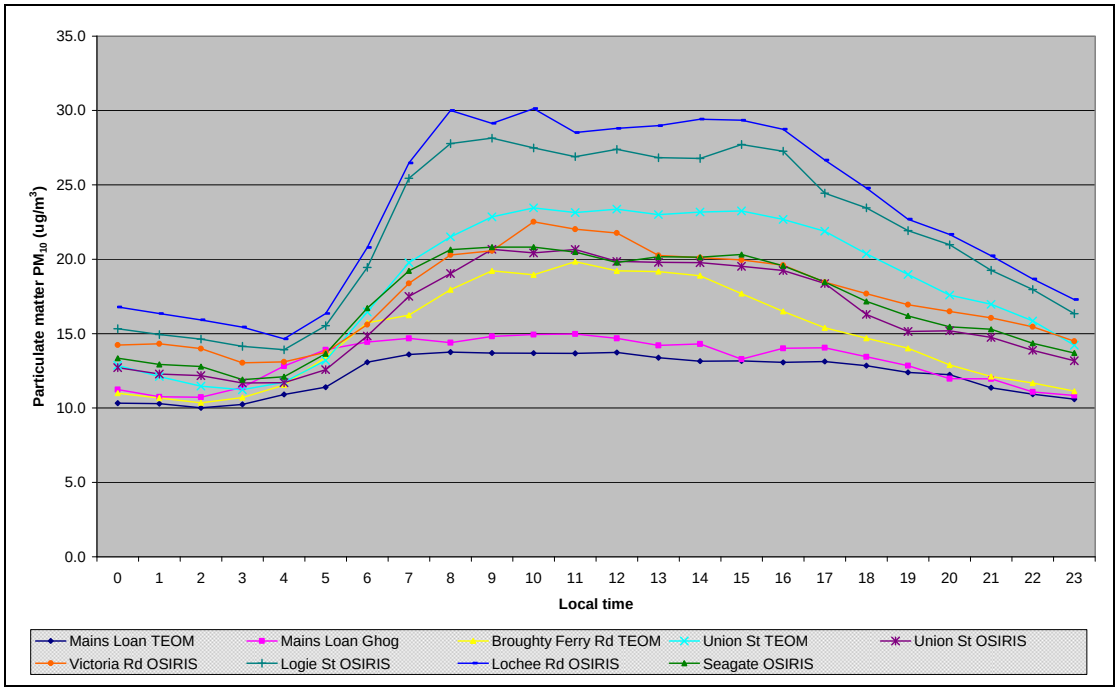


17th January to 9th February 2006 Data lost due to pump failure.
16th February to 23rd February2006 Data lost due to a downloading error.
1st August to 31st August 2006 No data due to annual service and calibration.

3.3.10 Diurnal PM_{10} Concentrations

Figure 3.3(16) shows the average PM_{10} concentrations for each hour of the day in 2006 at each automatic monitoring site. Local time rather GMT is used, to more closely reflect the daily cycle of man-made emissions. Increases in PM_{10} concentrations are observed at all sites during daytime hours and are greatest at those sites located close to busy roads and junctions.

Figure 3.3(16) - Comparison of Diurnal Variations in PM_{10} at All Sites in 2006



3.3.11 Discussion of Results

3.3.11.1 Annual mean PM_{10} Concentrations

The measured results for 2006, shown in **Box 3.3(i)**, demonstrate that the annual mean objective for PM_{10} (40 µg/m^3) in 2004 was achieved at all the monitoring locations in Dundee.

In order to compare the 2006 measured results with the 2010 annual mean objective (18 µg/m^3), the results were predicted forward and are shown in **Table 3.3b**. The 2010 annual mean objective is predicted to be achieved at the Broughty Ferry Road site (TEOM and Partisol) and the background site (Mains Loan) regardless of the gravimetric correction factor used. The predicted concentrations at the Union Street monitors exceed the 2010 objective except when the local gravimetric correction factor is used, the predicted value is 18.2 µg/m^3 which is very close to the objective. The Union Street monitors are located with the NO_2 monitor shown in ***Figure 3.2(15)***, and are within a street canyon between two bus stops. The sampling heads are approx. 1.35m from the kerb and 3.1m from the building facade.

The 2010 annual mean objective for PM_{10} is predicted to be exceeded at the following sites regardless of the local gravimetric correction factor used:

- Victoria Road / Hilltown Junction
- Seagate
- Logie Street
- Lochee Road

These sites are situated close to busy roads and junctions in Dundee which have been described in detail in the nitrogen dioxide section. The highest results are recorded at Lochee Road and Logie Street.

OSIRIS results are only considered suitable for screening assessments and are used to identify potential exceedence areas. This type of unit is not recommended for detailed assessments; hence additional gravimetric equivalent monitoring and / or modelling will be required at these 4 locations.

3.3.11.2 Trends in Annual mean PM_{10} Concentrations

Trends in concentrations are normally shown for sites with at least five years results. The long-term sites at Union Street and Broughty Ferry Road have been in place for 6 and 5 years respectively. A graph showing the trends in the measured annual means, (gravimetric equivalent 1.3) recorded at Union Street and Broughty Ferry Road are shown in ***Figure 3.3(5)***. The Broughty Ferry Road site shows a slight decline whereas Union Street appears to be increasing.

Recorded concentrations of PM_{10} in Union Street were higher in 2006 than when monitoring started in 2001. Levels at this urban roadside site are not exhibiting the predicted decline expected as a result of national emission reduction measures (e.g. stricter vehicle emission standards). The 2010 projected concentrations assume a declining trend which does not appear to be happening in this city centre location and hence these projections should be treated with caution. Additional gravimetric equivalent monitoring is required at this location as part of a detailed assessment for PM_{10}.

3.3.11.3 Background Annual Mean PM_{10} Concentrations

The PM_{10} annual mean concentrations for 2006, at background monitoring sites were found to be in generally good agreement with the AQ Archive estimated background concentrations (**Table 3.3c**). The closest correlation between measured and the nationally modelled background concentrations appears to be with the 1.14 factor.

Table 3.3c - Comparison of Measured Background Results for 2006 with the new AQ Archive estimated background concentrations for 2006.

2006 Background Annual mean PM_{10} for 1x1km grid square 340500E 731500N			
Measured			**Modelled**
Gravimetric factor	Mains Loan TEOM	Groundhog Mains Loan TEOM	Air Quality Archive
1.3	16.1	16.8	14.9
1.14	14.1	14.7	
1.05	13.0	13.6	

Neither of the background PM_{10} monitors were present for the full 12 months of 2006 and their annual mean results had to be annualised. Application of the local gravimetric correction factor (1.05) gives an annual mean value lower than that modelled nationally, which may suggest that the Air Quality Archive values are too high for Dundee.

Monitoring at the background site will be maintained and this observation will be reviewed once a full calendar year of data is available.

3.3.11.4 24 hour mean PM_{10} Concentrations

The measured results for 2006 in **Box 3.3(ii)** show that the 2004 24-hour mean objective (50µg/m^3 not to be exceeded more than 35 times in a year) has been achieved at all the monitoring locations in Dundee.

However, the 2010 24-hour mean objective only allows 7 exceedences of the standard. The 2006 results indicate that this objective was also achieved at all TEOM and Partisol monitoring locations in Dundee, (**Box 3.3(ii)**).

All the OSIRIS units recorded greater than 7 exceedences of the 24 hour objective. The OSIRIS unit in Union Street which is co-located with a TEOM recorded four times the number of exceedences (8 and 2 respectively). The response of the OSIRIS units to peak pollution levels is typically higher than the TEOM and this is thought to be the cause of the over-counting of exceedences by this type of unit.

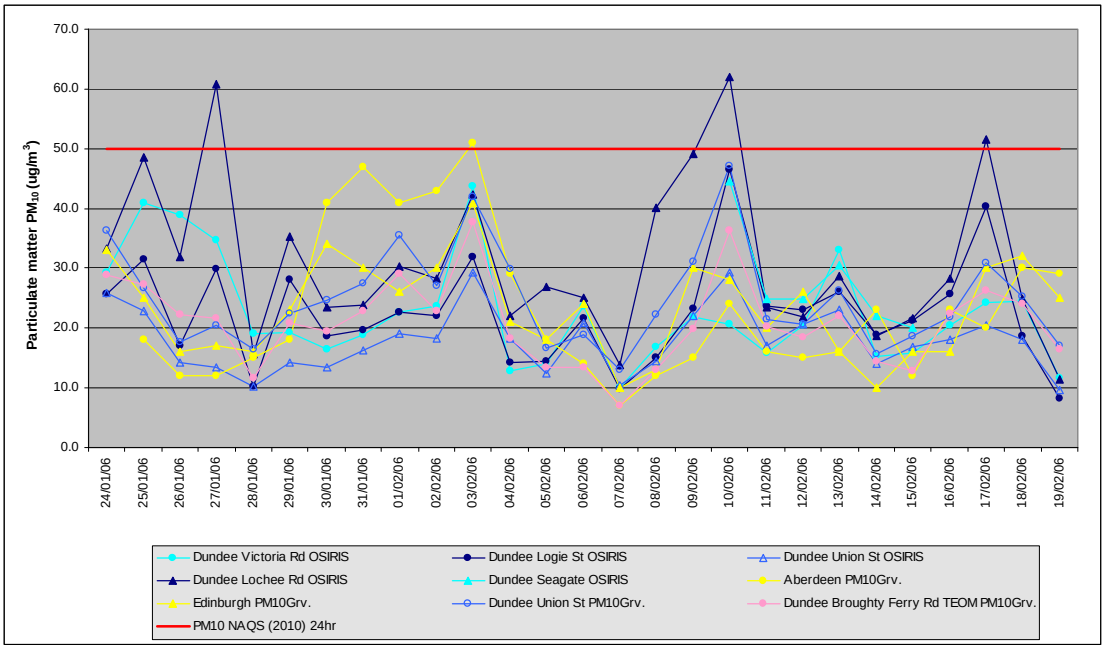
A detailed analysis of the wind speed and direction during the exceedences was carried out to try and establish, if possible, the likely sources of pollution. Wind speeds recorded in Dundee in 2006 ranged from 0.4 and 5.5 m/s with an average of 1.8 m/s. The exceedences were grouped into 10 episodes and compared with AURN urban background sites at Aberdeen and Edinburgh St. Leonards (see **Table 3.3d**). Five out of the ten episodes were associated with easterly winds. The episodes are examined in more detail in **Figures 3.3(17) to 3.3(24).**

Table 3.3d - PM_{10} 24 hour Exceedence Summary Table

					Urban background				Downwind of docks		Roadside					
	Dates of exceedences of the NAQS 24hr PM_{10} in Dundee		Average wind direction & speed (m/s)		Aberdeen PM_{10}Grv.	Edinburgh PM_{10}Grv.	Dundee Mains Loan1 PM_{10}Grv.	Dundee Groundhog DISC PM_{10}Grv.	Dundee Broughty Ferry Rd TEOM PM_{10}Grv.	Dundee Broughty Ferry Rd Partisol PM_{10}Grv.	Dundee Union St PM_{10}Grv.	Dundee Union St OSIRIS	Dundee Victoria Rd OSIRIS	Dundee Seagate OSIRIS	Dundee Logie St OSIRIS	Dundee Lochee Rd OSIRIS
1	27/01/2006	Fri	N	0.7	12	17	monitor not present until 28Mar06	monitor not present	22	monitor not present until 22Jun06	20	14	35	monitor not working	30	61
2	10/02/2006	Fri	W	0.8	24	28			36		47	29	21		47	62
3	17/02/2006	Fri	NW	1.1	20	30			26		31	20	24		40	52
4	24/03/2006	Fri	E	4	51	29		38	46		39	47	58	65	monitor not working	53
	25/03/2006	Sat	E	2	not working	16		24	36		38	66	66	78		48
5	04/05/2006	Thu	E	2.7	39	37	33	36	monitor not working		37	42	n/a	55	63	60
	05/05/2006	Fri	W	1.6	43	21	27	28			49	56	57	63	79	76
	07/05/2006	Sun	ENE	1.8	94	59	63	72			67	63	77	76	87	83
	08/05/2006	Mon	ENE	2.6	76	76	64	70			69	60	74	74	83	81
	09/05/2006	Tue	E	1.9	39	43	35	37			38	34	41	43	53	51
6	11/06/2006	Sun	SE	1.5	49	33	31	32	36		36	45	53	55	62	61
7	22/07/2006	Sat	ESE	1.4	31	32	34	38	35	32	38	35	43	44	54	54
	25/07/2006	Tue	ENE	1.4	monitor not working	36	32	35	35	28	34	32	39	40	52	52
	26/07/2006	Wed	ESE	1.1		38	40	43	43	35	43	40	49	50	66	64
8	11/10/2006	Wed	SE	3.1	41	22	19	monitor not present	24	32	29	52	55	42	54	52
	12/10/2006	Thu	SW	1.4	27	23	25		26	25	35	47	39	31	55	47
	13/10/2006	Fri	NE	1.1	34	36	33		36	23	42	62	68	47	79	72
	15/10/2006	Sun	ESE	0.9	31	36	35		35	31	36	40	42	27	54	43
	16/10/2006	Mon	SE	1.5	38	41	42		48	42	48	48	47	38	62	54
	17/10/2006	Tue	NE	1.5	45	47	45		49	53	50	82	91	58	92	82
	18/10/2006	Wed	WSW	1.3	24	26	19		23	24	30	37	34	25	55	40
	19/10/2006	Thu	E	2.2	31	19	22		29	26	28	45	44	34	52	48
	20/10/2006	Fri	ENE	1.5	25	24	26		34	28	32	59	63	44	69	64
9	27/11/2006	Mon	SSE	3.3	34	20	24		27	20	27	n/a	40	32	44	60
	29/11/2006	Wed	SW	2.7	22	21	22		27	16	35	42	34	27	38	52
10	18/12/2006	Mon	W	0.8	27	37	20		30	26	41	43	27	23	34	59
	TOTAL				3	2	2	2	0	1	2	8	10	8	18	22

EPISODES 1 to 3: 27th January, 10th February and 17th February 2006

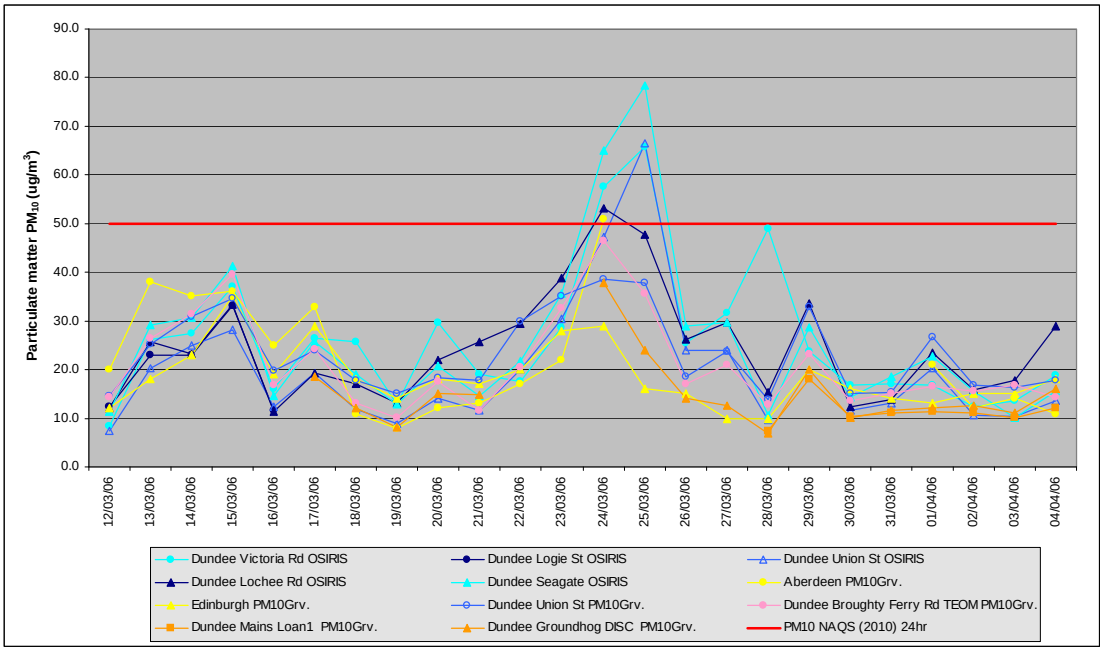
Figure 3.3(17) - Episodes 1 to 3: PM_{10} 24 hour exceedences



Each of the exceedences in ***Figure 3.3(17)*** were recorded at the Lochee Road OSIRIS on a Friday and are thought to be due to increased local traffic and congestion on this section of the north west arterial route. There were also relatively low wind speeds on these days which will not have aided the dispersal of pollutants within this canyoned area.

EPISODE 4: 24th and 25th March 2006

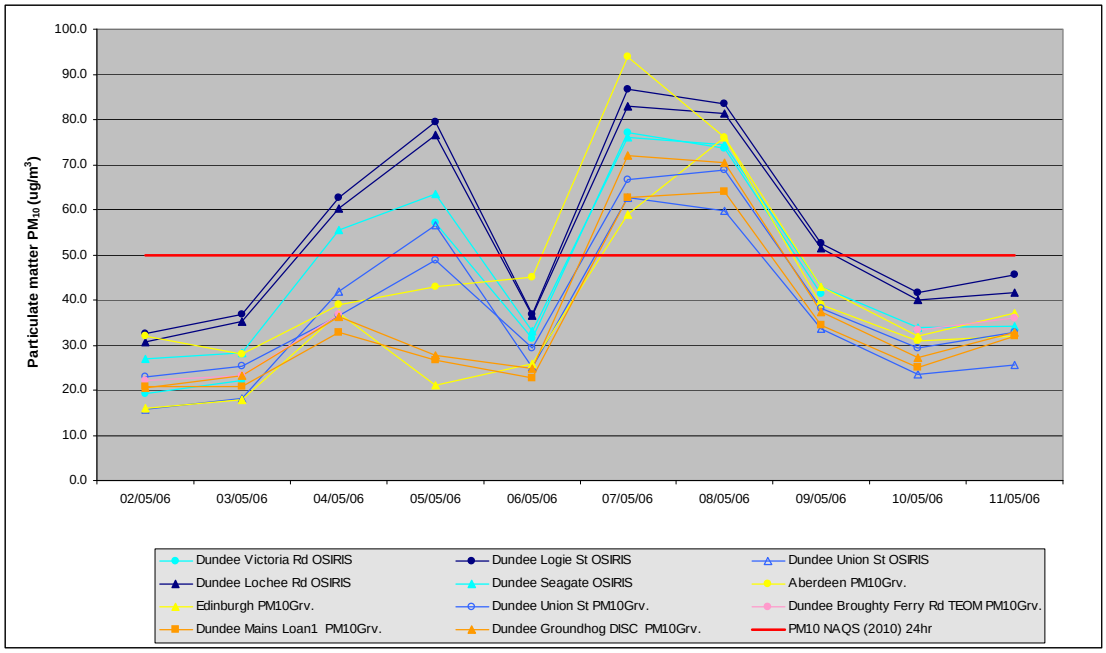
Figure 3.3(18) - Episode 4: PM_{10} 24 hour exceedences



The exceedences recorded during Episode 4 in March (***Figure 3.3(18)***) coincide with raised PM_{10} levels at the local and AURN urban background sites. Winds were predominantly from the east during this episode. Trans-boundary PM_{10} pollution from Eastern Europe is thought to have combined with local sources to cause these exceedences. The near exceedence at Victoria Road OSIRIS on the 28th is known to have been due to a local demonstration march which caused traffic congestion close to this monitor.

EPISODE 5: 4th to 9th May 2006

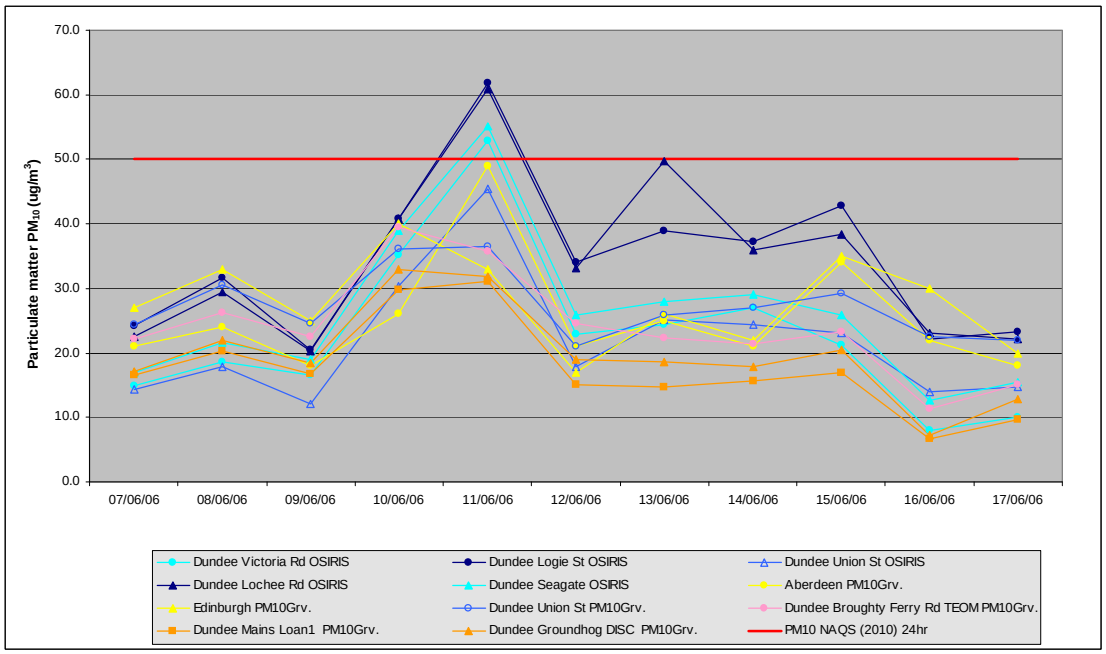
Figure 3.3(19) - Episode 5: PM_{10} 24 hour exceedences



Episode 5 as shown in ***Figure 3.3(19)*** was studied by AEAEE on behalf of DEFRA and the devolved administrations and is thought to have been caused by easterly winds bringing pollution from the continent including forest fires in Russia and high levels of pollen species from Denmark.

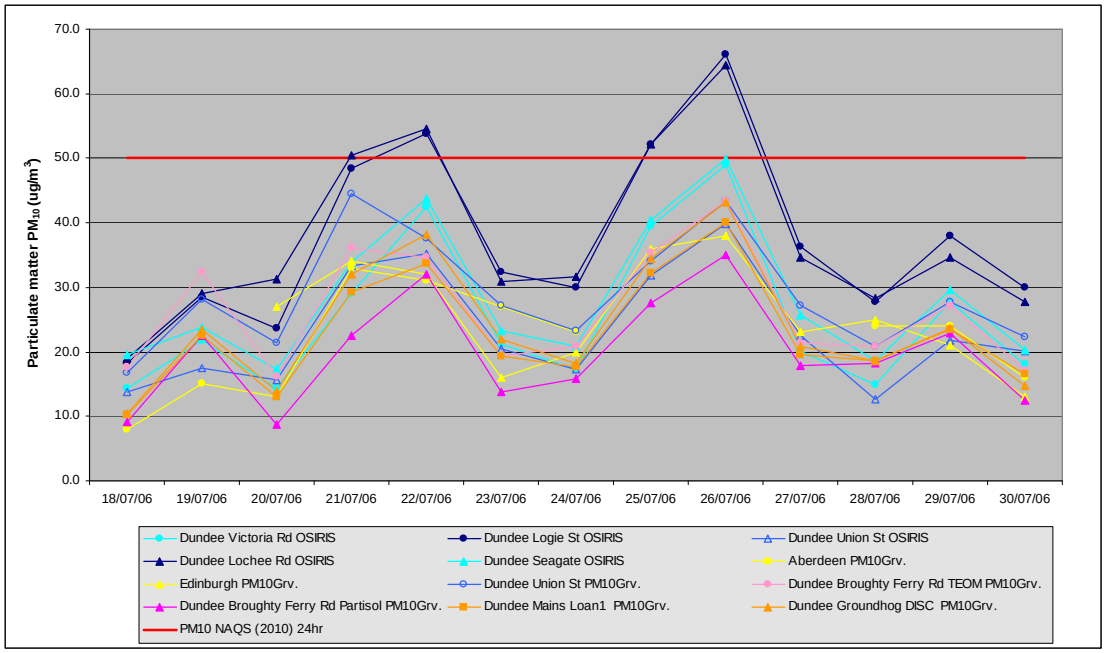
EPISODE 6: 11th June 2006

Figure 3.3(20) - Episode 6: PM_{10} 24 hour exceedences



EPISODE 7: 22nd to 26th July 2006

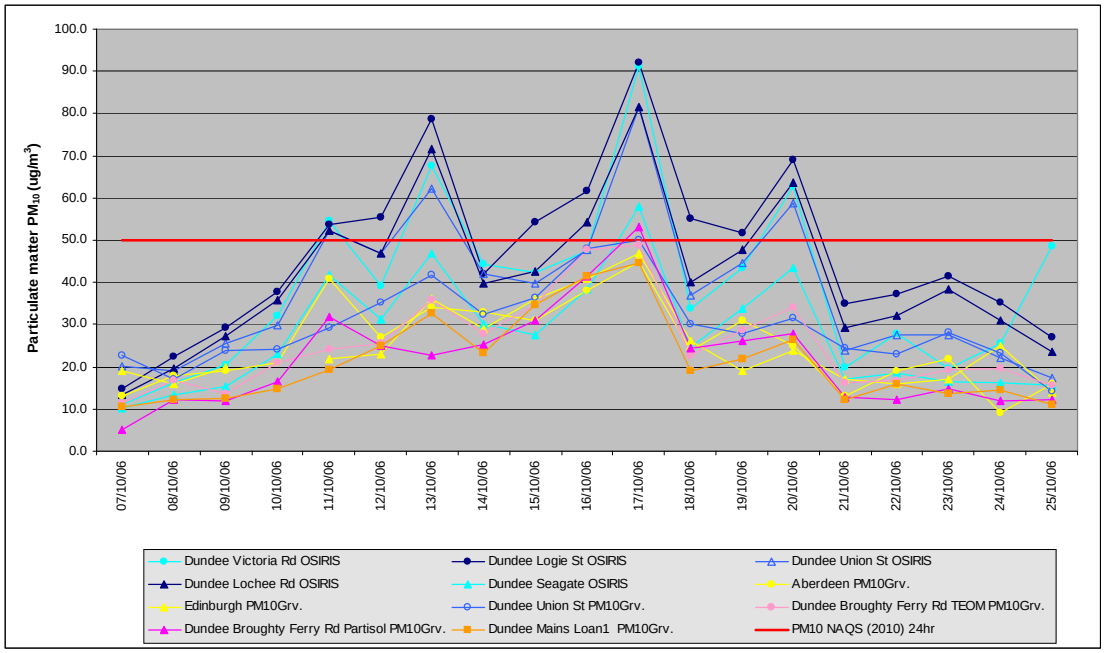
Figure 3.3(21) - Episode 7: PM_{10} 24 hour exceedences



Episodes 6 and 7 (***Figure 3.3(20) and Figure 3.3(21)***) show the exceedences that occurred in June and July these coincided with raised background levels at local and AURN urban background sites and moderate easterly winds. Trans-boundary PM_{10} pollution from Eastern Europe is thought to have combined with local sources to cause these exceedences.

EPISODE 8: 11th to 20th October 2006

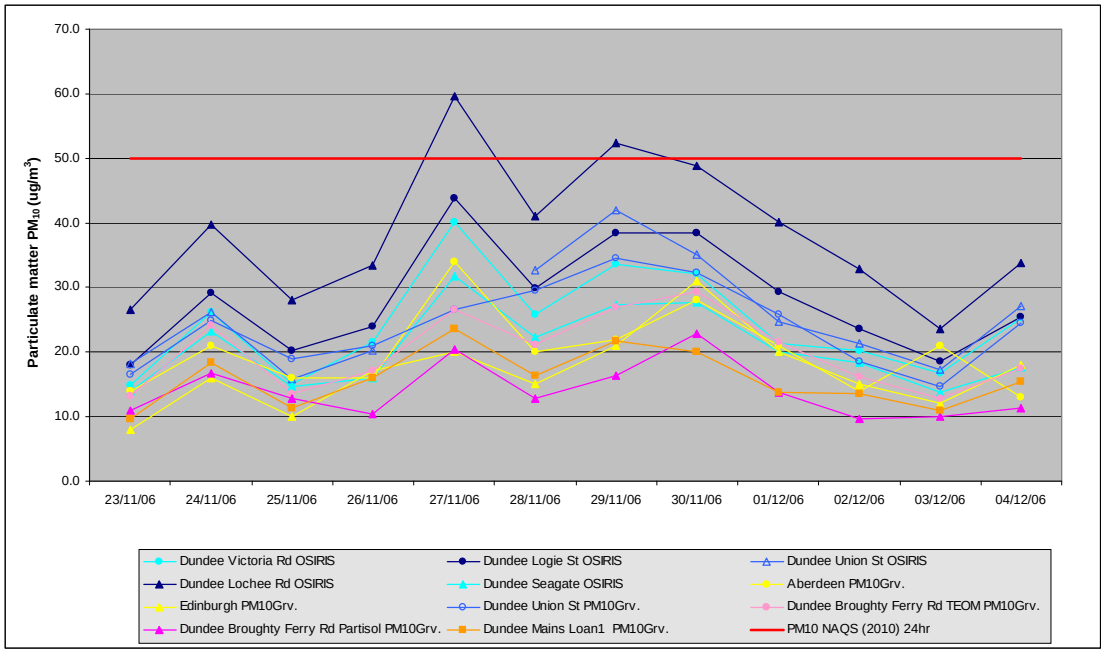
Figure 3.3(22) - Episode 8: PM_{10} 24 hour exceedences



Episode 8 (***Figure 3.3(22)***) shows the exceedences that occurred in October, these coincide with raised background levels at local and AURN urban background sites and predominately easterly winds. Lower than average wind speeds were recorded during this episode along with mist and fog. Trans-boundary PM_{10} pollution from Eastern Europe is thought to have contributed along with local meteorological conditions to cause these exceedences. There were also roadworks associated with the gas main renewal in Lochee Road at this time.

EPISODE 9: 27th to 29th November 2006

Figure 3.3(23) - Episode 9: PM_{10} 24 hour exceedences

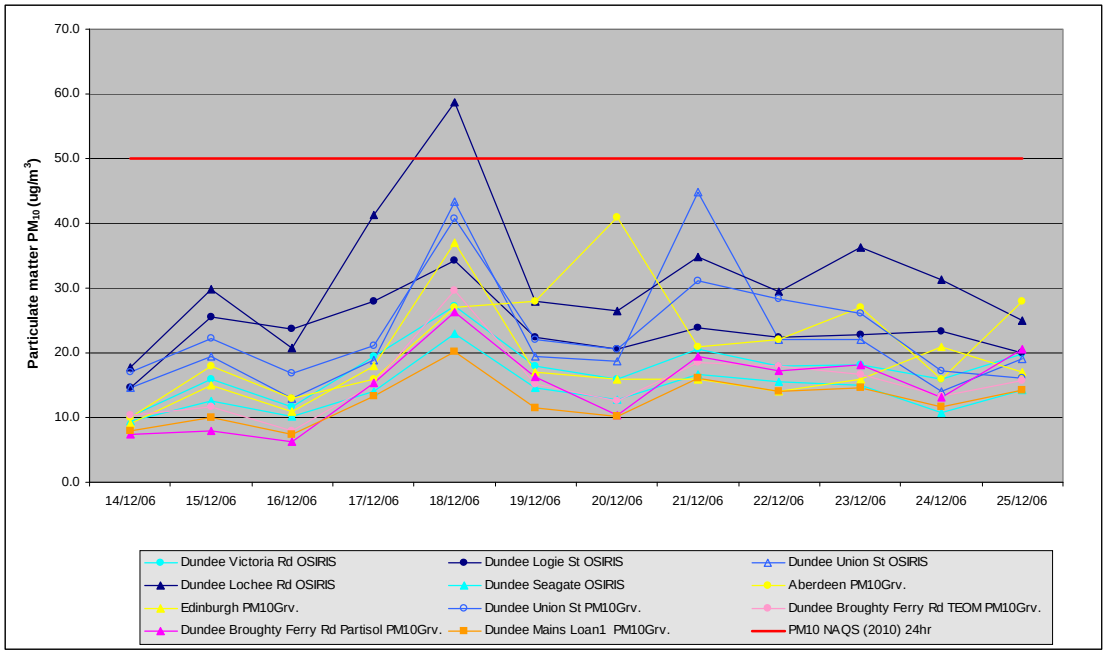


Episode 9 (***Figure 3.3(23)***) shows the exceedences that occurred in November. These coincide with raised background levels at local and AURN urban background site, and predominately southerly winds. Although raised levels were also seen at the Edinburgh background site, they didn't peak as quickly.

The cause of the raised background levels is unknown but affected Aberdeen and Edinburgh also. A combination of this raised background and local sources, including roadworks at Lochee Road, are considered to be the cause of these exceedences.

EPISODE 10: 18th December 2006

Figure 3.3(24) - Episode 10: PM_{10} 24 hour exceedence



Episode 10 (***Figure 3.3(24)***) shows the exceedence that occurred in December, this coincided with raised background levels at local and AURN urban background sites and predominately westerly winds. Low temperatures and low wind speeds were recorded during this episode and are thought to have hindered the dispersal of pollutants during this episode. Increased traffic on the roads at this time of year may also have contributed to this exceedence.

3.3.11.5 Trends in 24 hour mean PM_{10} Concentrations

Trends in concentrations are normally shown for sites with at least five years results. The long-term sites at Union Street and Broughty Ferry Road have been in place for 6 and 5 years respectively. A graph showing the trends in the 90th and 98th percentile values, (gravimetric equivalent 1.3) recorded at Union Street and Broughty Ferry Road are shown in **Box 3.3(iii) and 3.3(iv)**. both sites show a slight decline from 2003 which was a higher than usual pollution year.

3.3.12 Conclusion

Section 3.3.6 presented the results of Dundee City Council's local gravimetric factor study. This study established a local gravimetric correction factor of 1.05. Even when the local factor is used there are still exceedences of the 2010 PM_{10} annual mean objective predicted at the following locations:

- Victoria Road / Hilltown Junction
- Seagate
- Logie Street
- Lochee Road

Union Street is also very close to exceeding the annual mean objective in 2010. However, analysis of the trend in the annual means at this site show that concentrations are increasing and it should be considered to remain an area of concern for PM_{10}.

There are also potential exceedences of the 24 hour objective predicted at these locations, measured using OSIRIS units. OSIRIS results are only considered suitable for screening assessments and are used to identify potential exceedence areas. This type of unit is not recommended for detailed assessments; hence additional gravimetric equivalent monitoring and / or modelling will be required at these 5 locations.

The PM_{10} results indicate that a detailed assessment of PM_{10} will be required.

3.4 SULPHUR DIOXIDE (SO_2)

OBJECTIVES :

266 micrograms per cubic metre or less, when expressed as a 15-minute mean, not to be exceeded more than 35 times a year to be achieved by 31st December 2005.

350 micrograms per cubic metre or less, when expressed as an hourly mean, not to be exceeded more than 24 times a year to be achieved by 31st December 2004.

125 micrograms per cubic metre or less, when expressed as a 24-hour mean, not to be exceeded more than 3 times a year to be achieved by 31st December 2004.

3.4.1 Measurement Method

The sulphur dioxide (SO_2) analyser works on the principle of ultra-violet (UV) fluorescence. SO_2 molecules are excited to higher energy states by UV radiation. These energy states decay causing emission of secondary fluorescent radiation with an intensity that is proportional to the concentration of SO_2 in the sample.

3.4.2 Instrumentation

Each site monitoring SO_2 is equipped with a Monitor Labs 9850 analyser.

3.4.3 Data Quality Requirements

The analyser is calibrated every night using certified calibration gases. Data has been screened and scaled in accordance with the Technical Guidance (LAQM.TG03). The analyzer is audited twice yearly by AEAEE and data for 2006 has been ratified by AEAEE.

3.4.4 Summary of Annual Results

Automatic monitoring results for the period 1 January to 31 December 2006 are shown in **Box 3.4(i)** and **Tables 3.4a and 3.4b**, along with results for previous years.

Box 3.4(i) - Summary of 15-minute mean SO_2 Results ($\mu g/m^3$) from Continuous Monitors (NAQS = 266$\mu g/m^3$)

NAQS SO_2 (15min)								
Year	Broughty Ferry Road Rollalong				Groundhog Mains Loan			
	No.of exceedences (>266ug/m^3)*	99.9th Percentile	Max (ug/m^3)	data capture (%)	No.of exceedences (>266ug/m^3)*	99.9th Percentile	Max (ug/m^3)	data capture (%)
2002	1	165	288	90.4				
2003	6	117	392	95.4				
2004	5	57	395	97.9	0	22	83	54.8
2005	2	90	281	93.0				
2006	5	72	572	94.5	0	27	51	47.0

*To achieve the NAQS(SO2)15min objective, no more than 35 exceedences of 266ug/m^3 are allowed per calender year

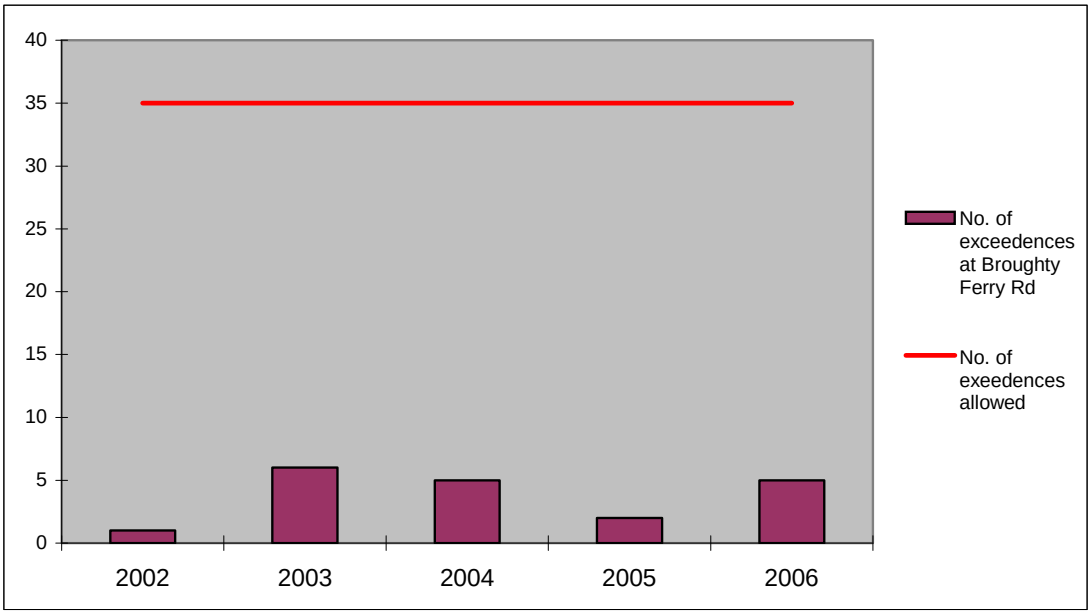


Table 3.4a - Summary of 1-hour mean SO_2 Results ($\mu g/m^3$) from Continuous Monitors (NAQS = 350$\mu g/m^3$)

NAQS SO_2 (1 hour)								
Year	Broughty Ferry Road Rollalong				Groundhog Mains Loan			
	No.of exceedences (>350ug/m^3)*	99.7th Percentile	Max (ug/m^3)	data capture (%)	No.of exceedences (>350ug/m^3)*	99.7th Percentile	Max (ug/m^3)	data capture (%)
2002	0	100	207.7	92.0				
2003	0	61	267.3	97.5				
2004	0	39	294.2	100.0	0	16	22.3	50.5
2005	0	54	235.1	95.0				
2006	0	46	277.5	96.6	0	16	32.8	48.0

*To achieve the NAQS 1hrly objective for SO_2, no more than 24 exceedences of 350ug/m^3 are allowed per calender year

Table 3.4b - Summary of 24-hour mean SO_2 Results ($\mu g/m^3$) from Continuous Monitors (NAQS = 125$\mu g/m^3$)

NAQS SO_2 (24 hour)								
Year	Broughty Ferry Road Rollalong				Groundhog Mains Loan			
	No.of exceedences (>125ug/m^3)*	99th Percentile	Max (ug/m^3)	data capture (%)	No.of exceedences (>125ug/m^3)*	99th Percentile	Max (ug/m^3)	data capture (%)
2002	0	38	69.7	92.1				
2003	0	27	53.7	97.3				
2004	0	18	33.3	100.0	0	5	6.1	55.2
2005	0	21	54.0	94.8				
2006	0	20	49.2	96.4	0	4	4.9	47.7

*To achieve the NAQS 24hrly objective for SO_2, no more than 3 exceedences of 125ug/m^3 are allowed per calender year

3.4.5 15-minute Average Concentrations of SO_2 in 2006

The figures below shows the time series graph of 15-minute average SO_2 concentrations for the Broughty Ferry Road monitoring site and the Groundhog which was located in Dundee between the 17 March and 17 September 2006. The 15-minute average is shown instead of the hourly or 24-hourly averages as this is the strictest objective to meet, and is the only one for which there are recorded exceedences.

Figure 3.4(1) - Time Series at Broughty Ferry Road of SO_2 15-Minute Averages in 2006 ($\mu g/m^3$)

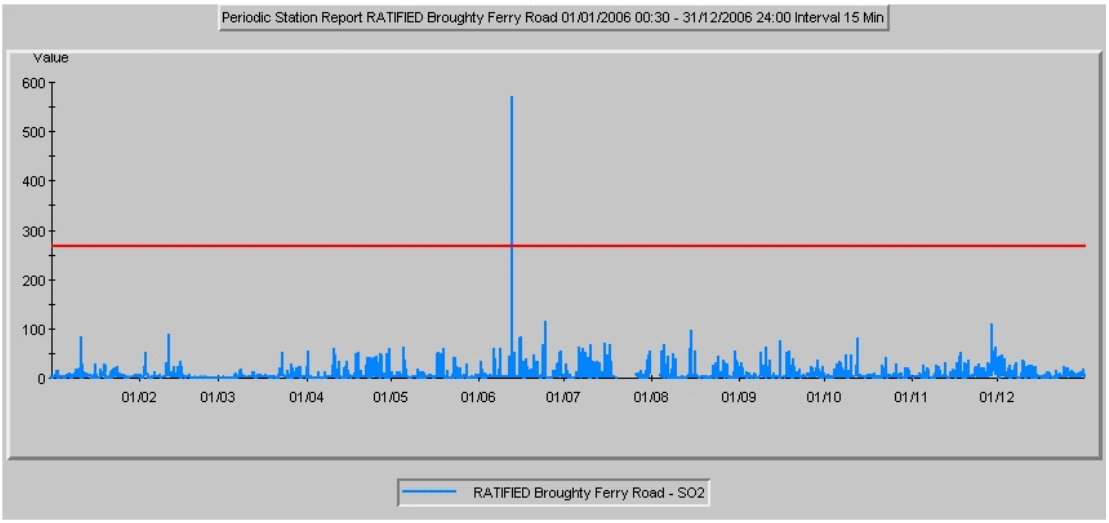
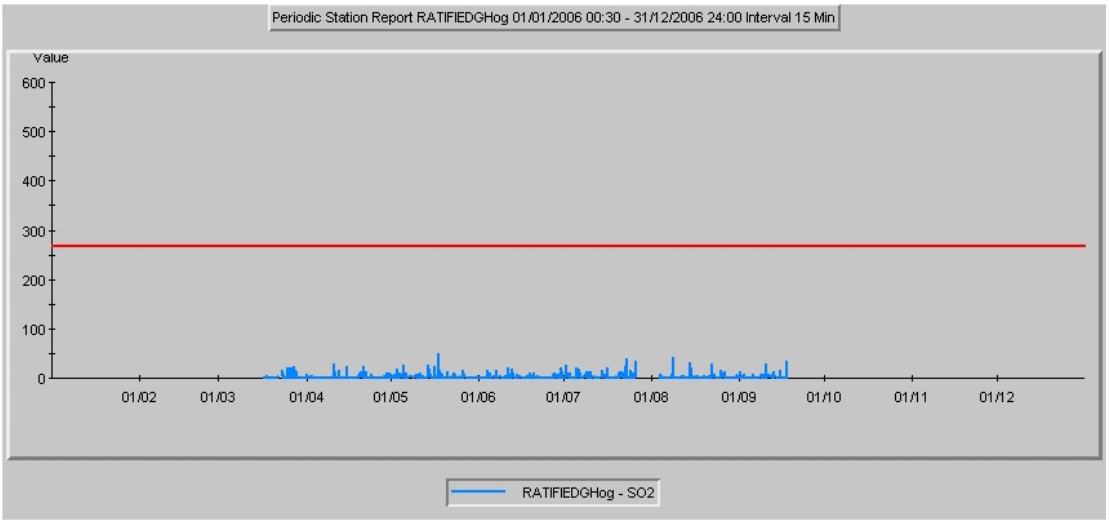


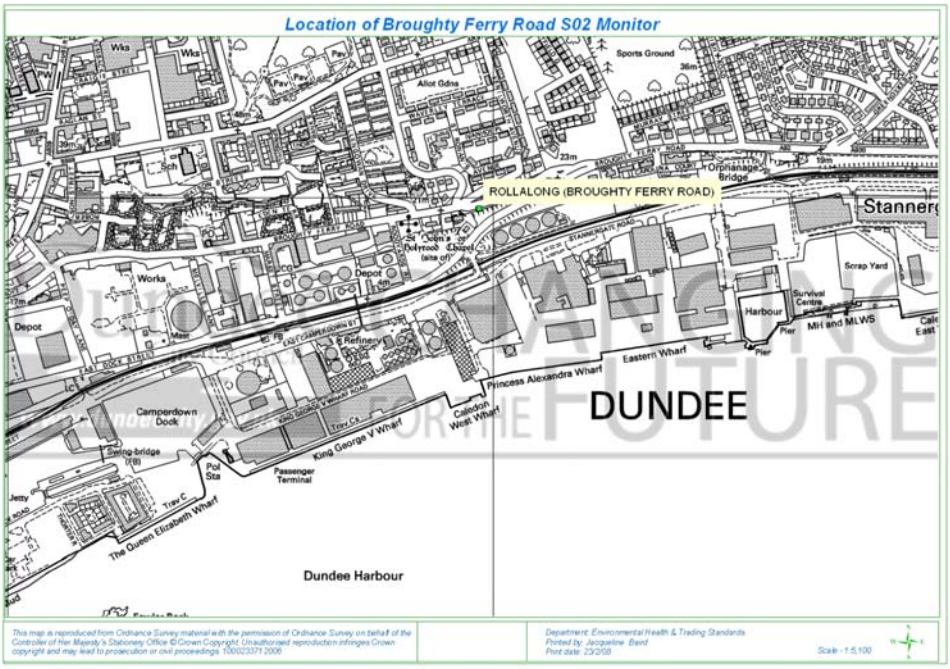
Figure 3.4(2) - Time Series at Groundhog Mains Loan of SO_2 15-Minute Averages in 2006 ($\mu g/m^3$)



3.4.6 Discussion of Results

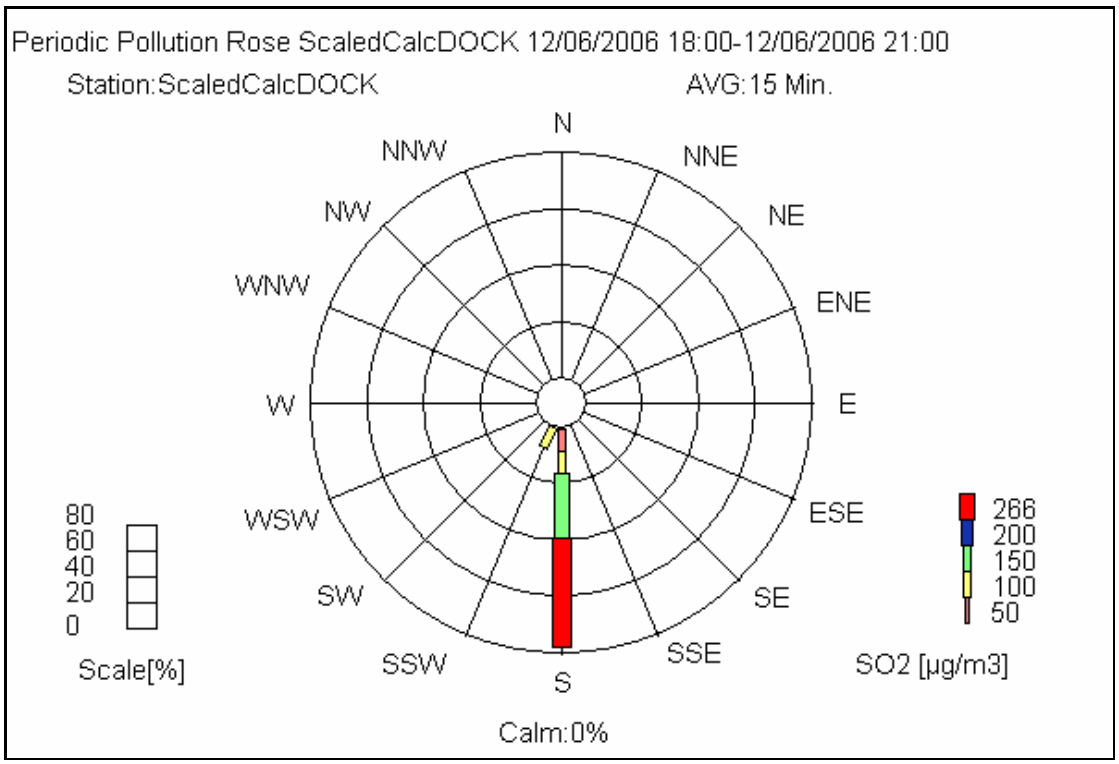
There were 5 exceedences of the 15-minute mean objective for sulphur dioxide (266µg/m^3) at the Broughty Ferry Road monitor during 2006. These occurred on the evening of the 12th June 2006 between 18:00 and 21:00 hours. The cause is thought to be due to a tanker which was docked at the Caledon West Wharf to the south of the monitor at this time. A map showing the proximity of this monitor to industrial sources and shipping is shown in ***Figure 3.4(3).***

Figure 3.4(3) - Broughty Ferry Road SO_2 Monitor



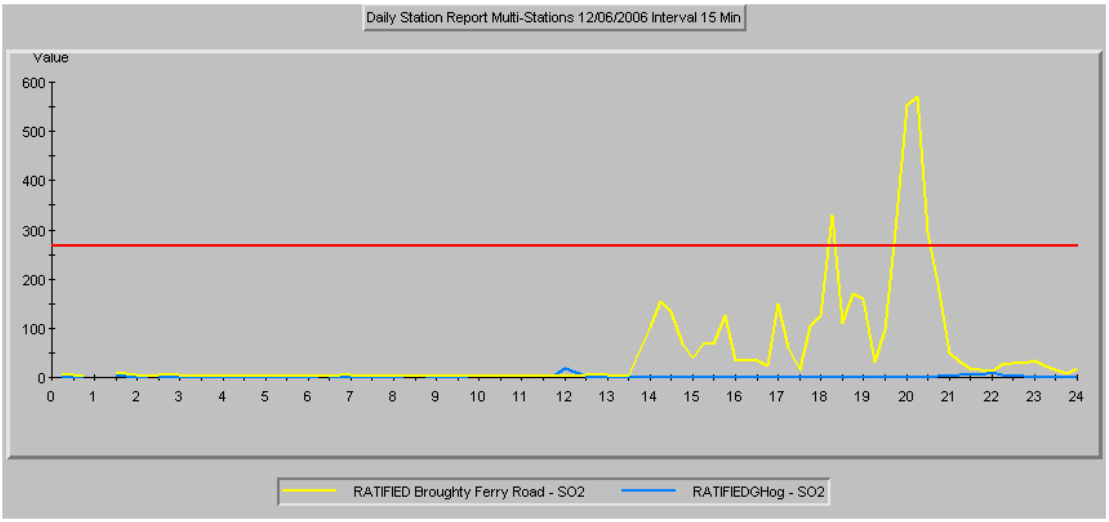
The pollution rose for this time period (see ***Figure 3.4(4)***) indicates that the wind and pollution was predominantly from the south. This would suggest that the exceedences were associated with sources within the docks area. There are 35 exceedences permitted within each calendar year.

Figure 3.4(4) - Pollution Rose for Broughty Ferry Road Monitor 18:00 to 21:00 on 12th June 2006.



A comparison of measured SO_2 levels for this time period at the Broughty Ferry Road site and the background site at Mains Loan Groundhog is shown in ***Figure 3.4(5)*** and confirms that the raised SO_2 levels were local to the Broughty Ferry Road Site.

Figure 3.4(5) - Comparison of Broughty Ferry Road and Groundhog Mains Loan SO_2 15-Minute Averages on 12/06/06 (µg/m³)



There were no recorded exceedences of the one-hour nor the 24-hour objectives for sulphur dioxide at the Broughty Ferry Road monitor during 2006.

3.4.7 Trends in Annual SO_2 Concentrations

Trends in concentrations are normally shown for sites with at least five years results. The longest period of SO_2 measurement available in Dundee are the five years from the Broughty Ferry Road monitor.

Figure 3.4(6) shows a comparison in the trend in 99.9th percentile and maximum SO_2 15 minute averages for the Broughty Ferry Road Site with the AURN urban background sites in Aberdeen and Edinburgh St. Leonards.

Figure 3.4(6) - Trends in 99.9th Percentile and Maximum SO_2 15-Minute Averages ($\mu g/m^3$) at Broughty Ferry Road compared with AURN Urban Background Sites

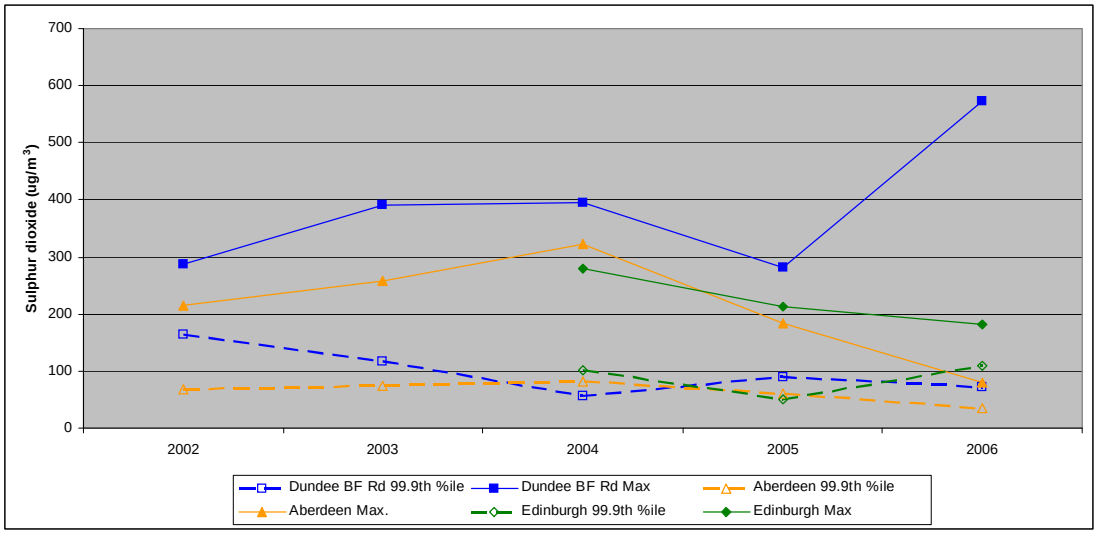


Figure 3.4(6) clearly shows that the maximum values recorded at the Broughty Ferry Road site are consistently higher in all years than the urban background sites due to it's proximity to industrial sources and shipping. The trend in 99.9th percentile values shows a decline at the Broughty Ferry Road site since the introduction in 2003 of low sulphur fuels at industrial plant in the vicinity of the monitor.[18]

3.4.8 Conclusion

The monitoring results for 2006 indicate that all the NAQS objectives were met at monitoring locations in Dundee. Exceedences of the 15min objective occurred at the Broughty Ferry Road site; these were well below the 35 exceedences allowed and were thought to be caused by certain shipping movements and activities.

[18] The Sulphur Content of Liquid Fuels (Scotland) Regulations 2002.

SECTION 4 NEW LOCAL DEVELOPMENTS

This section is included to highlight any changes that have taken place that may affect air quality, and includes :

- new industrial processes included in the list in Appendix 2 of LAQM.TG(03), i.e. Part A, A2 or B processes;
- new developments with an impact on air quality, especially those that will significantly change traffic flows;
- new landfill sites, quarries etc. that have been granted planning permission, and which have nearby relevant exposure (see Box 8.4 in LAQM.TG(03), page 8-33).

4.1 NEW PART A PROCESSES

There have been no new Part A Processes since the last round of review and assessment.

4.2 NEW PART B PROCESSES

There have been no new Part B Processes since the last round of review and assessment.

4.3 NEW RETAIL DEVELOPMENT

An air quality assessment has been received for a proposed new superstore on South Road, no exceedences of the air quality objectives were predicted.

In addition, a revised air quality assessment is awaited for the proposed retail expansion of the Overgate Centre.

A new superstore has opened near to the junction of two trunk roads; the Kingsway / Forfar Road junction. An air quality screening assessment has predicted that the extra traffic and necessary junction works associated with the superstore will lead to an exceedence of the PM_{10} annual mean objective (2010) at existing receptors close to this junction. A six month monitoring study of PM_{10} will commence in the area once the junction works are completed to check the accuracy of the modelled predictions.

The 2006 diffusion tube monitoring in the same area has also identified a potential exceedence of annual mean objective for NO_2. The extra traffic generated by the development may also have an impact on NO_2 concentrations in this area and monitoring will be continued in the vicinity of this junction.

4.4 NEW ROAD SCHEMES

There have been no new road schemes since the last round of review and assessment.

4.5 NEW MINERAL DEVELOPMENT

There have been no new mineral developments within or close to the Dundee City Council boundary since the last round of review and assessment.

4.6 NEW LANDFILL DEVELOPMENT

There have been no new landfill developments within or close to the Dundee City Council boundary since the last round of review and assessment.

4.7 NEW MIXED USE DEVELOPMENT

There have been no new mixed use developments since the last round of review and assessment.

SECTION 5 CONCLUSIONS

The new monitoring results for 2006 indicate that:

5.1 NITROGEN DIOXIDE

The majority of measured 2006 annual mean tube results increased over that measured in 2005. There continue to be areas where the 2005 Annual mean standard of 40 µg/m³ is exceeded and hence a continued need for the AQMA and development of an Action Plan. Two new areas of potential exceedence of the annual mean have been identified at the Kingsway/Forfar Road and Arbroath Road/Albert Street Junctions.

The hourly objective for nitrogen dioxide was achieved at all monitoring locations.

5.2 SMALL PARTICULATES (PM_{10})

Dundee City Council's Partisol vs TEOM intercomparison study established a local gravimetric correction factor of 1.05. Even when the local factor is applied there are still exceedences of the 2010 PM_{10} annual mean objective predicted at the following locations:

- Victoria Road / Hilltown Junction;
- Seagate;
- Logie Street; and
- Lochee Road.

Union Street is also predicted to be very close to exceeding the annual mean objective in 2010. Analysis of trends in the annual means at this site show the PM_{10} concentrations at this city centre location are increasing and this also remains an area of concern.

In addition there are potential exceedences of the 24 hour objective predicted at the above locations, measured using OSIRIS units. OSIRIS results are only considered suitable for screening assessments and are used to identify potential hotspot areas. This type of unit is not recommended for detailed assessments; hence additional gravimetric equivalent monitoring and / or modelling will be required at these 5 locations.

The 2006 PM_{10} results indicate that a detailed assessment of PM_{10} will be required.

5.3 SULPHUR DIOXIDE

The monitoring results for 2006 indicate that the all the NAQS objectives were met at monitoring locations in Dundee. Exceedences of the 15min objective occurred at the Broughty Ferry Road site, these were well below the 35 exceedences allowed and were thought to be caused by certain shipping

movements and activities. A detailed assessment is not currently required for this pollutant.

5.4 NEW LOCAL DEVELOPMENTS

New local developments with the potential to affect air quality have been identified in Section 4. Of these, the one that could potentially result in a new area of exceedence is the new superstore which has opened near to the junction of two trunk roads; i.e. the Kingsway / Forfar Road junction.

It has been predicted that the extra traffic and necessary junction works associated with the superstore will lead to an exceedence of the PM_{10} annual mean objective (2010) at existing receptors close to this junction. A six month monitoring study of PM_{10} will commence in the area once the junction works are completed to check the accuracy of the modelled predictions.

The 2006 diffusion tube monitoring in the same area has also identified a potential exceedence of annual mean objective for NO_2. The extra traffic generated by the development may also have an impact on NO_2 concentrations in this area and monitoring will be continued in the vicinity of this junction.

It is recommended that a steering group be created to oversee the action plan for air quality. This should facilitate closer inter-departmental working to ensure new planned developments and infrastructure improvements are sensitive to air quality concerns, and provide sufficient information to quantify the improvements already being made in air quality terms through local transport initiatives.

APPENDIX 1: BIAS ADJUSTMENT CALCULATIONS FOR COLLOCATION STUDIES

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	04/01/2006	31/01/2006	50.6	55.0	54.6	53	2.4	5	6.0	67.3	92.3	Good	Good
2	31/01/2006	28/02/2006	58.5	64.2	59.6	61	3.0	5	7.5	58.9	97.4	Good	Good
3	28/02/2006	04/04/2006	53.0	52.7	56.1	54	1.9	3	4.7	51.9	96	Good	Good
4	04/04/2006	02/05/2006	44.8	57.8	47.8	50	6.8	14	16.9	54.7	80.4	Good	Good
5	02/05/2006	30/05/2006	42.9	43.4	47.4	45	2.5	6	6.1	37	96.5	Good	Good
6	30/05/2006	27/06/2006	46.8	49.1	42.5	46	3.4	7	8.3	37	67.2	Good	Poor Data Capture
7	27/06/2006	01/08/2006	51.9	44.0	37.8	45	7.1	16	17.6	41	55.6	Good	Poor Data Capture
8	01/08/2006	29/08/2006	44.0	44.5	48.4	46	2.4	5	6.0			Good	
9	29/08/2006	03/10/2006		50.3						42	55.9		Poor Data Capture
10	03/10/2006	31/10/2006	43.9	46.5	44.4	45	1.4	3	3.4			Good	
11	31/10/2006	28/11/2006	47.1	43.7	45.8	46	1.7	4	4.3	47	20.4	Good	Poor Data Capture
12	28/11/2006	03/01/2007	63.4	65.1	61.0	63	2.1	3	5.1	51.5	83.2	Good	Good
13													
												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

Overall survey -->

Site Name/ ID:	Dundee Lochee Rd

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

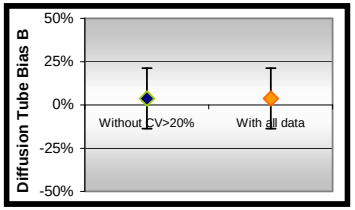
(Check average CV & DC from Accuracy calculations)

Accuracy (with 95% confidence interval)
without periods with CV larger than 20%
Bias calculated using 6 periods of data

Bias factor A	0.98 (0.84 - 1.19)
Bias B	2% (-16% - 19%)
Diffusion Tubes Mean:	54 μgm^{-3}
Mean CV (Precision):	6
Automatic Mean:	53 μgm^{-3}
Data Capture for periods used:	91%
Adjusted Tubes Mean:	53 (46 - 65) μgm^{-3}

Accuracy (with 95% confidence interval)
WITH ALL DATA
Bias calculated using 6 periods of data

Bias factor A	0.98 (0.84 - 1.19)
Bias B	2% (-16% - 19%)
Diffusion Tubes Mean:	54 μgm^{-3}
Mean CV (Precision):	6
Automatic Mean:	53 μgm^{-3}
Data Capture for periods used:	91%
Adjusted Tubes Mean:	53 (46 - 65) μgm^{-3}



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Version 03 - November 2006

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	04/01/2006	31/01/2006	58.0	60.2	57.9	59	1.3	2	3.2			Good	
2	31/01/2006	28/02/2006	56.3	50.0	55.1	54	3.3	6	8.3			Good	
3	28/02/2006	04/04/2006	47.0	45.7	45.4	46	0.9	2	2.1			Good	
4	04/04/2006	02/05/2006	52.1	46.6	52.8	51	3.4	7	8.4			Good	
5	02/05/2006	30/05/2006	35.7	41.8	38.9	39	3.1	8	7.6	21.4	13.4	Good	Poor Data Capture
6	30/05/2006	27/06/2006	39.8	42.6	43.7	42	2.0	5	5.0	25.4	97.0	Good	Good
7	27/06/2006	01/08/2006	46.6	45.4	40.0	44	3.5	8	8.7	34.2	97.8	Good	Good
8	01/08/2006	29/08/2006	42.9	45.1	42.6	44	1.4	3	3.4	30.0	97.5	Good	Good
9	29/08/2006	03/10/2006	53.4	53.5	47.9	52	3.2	6	8.0	40.5	97.7	Good	Good
10	03/10/2006	31/10/2006	56.7	51.7	53.0	54	2.6	5	6.4	42.6	97.7	Good	Good
11	31/10/2006	28/11/2006	57.6	59.5	62.1	60	2.3	4	5.6	49.5	97.2	Good	Good
12	28/11/2006	03/01/2007	58.4	56.0	62.3	59	3.2	5	7.9	42.1	99.4	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

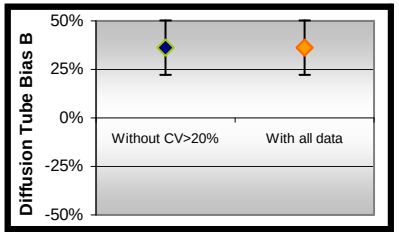
(Check average CV & DC from Accuracy calculations)

Site Name/ ID:	Dundee Union Street

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 7 periods of data	
Bias factor A	0.75 (0.68 - 0.84)
Bias B	34% (20% - 48%)
Diffusion Tubes Mean:	51 μgm^{-3}
Mean CV (Precision):	5
Automatic Mean:	38 μgm^{-3}
Data Capture for periods used:	98%
Adjusted Tubes Mean:	38 (34 - 42) μgm^{-3}

Accuracy (with 95% confidence interval) WITH ALL DATA	
Bias calculated using 7 periods of data	
Bias factor A	0.75 (0.68 - 0.84)
Bias B	34% (20% - 48%)
Diffusion Tubes Mean:	51 μgm^{-3}
Mean CV (Precision):	5
Automatic Mean:	38 μgm^{-3}
Data Capture for periods used:	98%
Adjusted Tubes Mean:	38 (34 - 42) μgm^{-3}



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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	04/01/2006	31/01/2006	58.1	56.3	57.6	57	0.9	2	2.3	41.9	94.4	Good	Good
2	31/01/2006	28/02/2006	60.6	61.2	54.4	59	3.8	6	9.4	38.2	97.9	Good	Good
3	28/02/2006	04/04/2006	54.6	58.2	58.9	57	2.3	4	5.7	41.1	86.8	Good	Good
4	04/04/2006	02/05/2006	48.5	52.6	51.8	51	2.2	4	5.4	39.9	96.7	Good	Good
5	02/05/2006	30/05/2006	55.4	61.8	62.8	60	4.0	7	10.0	52	91.8	Good	Good
6	30/05/2006	27/06/2006	51.5	37.7	48.9	46	7.3	16	18.2	42	89.3	Good	Good
7	27/06/2006	01/08/2006	54.0	58.7	59.4	57	2.9	5	7.3	50	52.9	Good	Poor Data Capture
8	01/08/2006	29/08/2006	47.7	46.9	48.0	48	0.6	1	1.4			Good	
9	29/08/2006	03/10/2006	54.3	59.6	51.0	55	4.3	8	10.8			Good	
10	03/10/2006	31/10/2006	55.6	52.4	60.7	56	4.2	7	10.4			Good	
11	31/10/2006	28/11/2006	48.1	48.4	52.6	50	2.5	5	6.2	50.7	31.1	Good	Poor Data Capture
12	28/11/2006	03/01/2007	55.9	51.8	57.5	55	2.9	5	7.3	49.2	83.1	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

Site Name/ ID:	Dundee Seagate

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

(Check average CV & DC from Accuracy calculations)

Accuracy (with 95% confidence interval)
without periods with CV larger than 20%

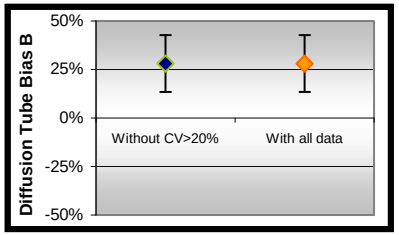
Bias calculated using 7 periods of data

Bias factor A	0.79 (0.71 - 0.89)
Bias B	27% (12% - 42%)
Diffusion Tubes Mean:	55 μgm^{-3}
Mean CV (Precision):	6
Automatic Mean:	43 μgm^{-3}
Data Capture for periods used:	91%
Adjusted Tubes Mean:	43 (39 - 49) μgm^{-3}

Accuracy (with 95% confidence interval)
WITH ALL DATA

Bias calculated using 7 periods of data

Bias factor A	0.79 (0.71 - 0.89)
Bias B	27% (12% - 42%)
Diffusion Tubes Mean:	55 μgm^{-3}
Mean CV (Precision):	6
Automatic Mean:	43 μgm^{-3}
Data Capture for periods used:	91%
Adjusted Tubes Mean:	43 (39 - 49) μgm^{-3}



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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	04/01/2006	31/01/2006	51.2	46.9	47.6	49	2.3	5	5.7	45.2	96.2	Good	Good
2	31/01/2006	28/02/2006	47.1	46.9	46.4	47	0.4	1	0.9	41.7	96.2	Good	Good
3	28/02/2006	04/04/2006	45.5	47.9	46.5	47	1.2	3	3.0	43.3	96.7	Good	Good
4	04/04/2006	02/05/2006	39.1	40.8	40.5	40	0.9	2	2.3	35.2	95.8	Good	Good
5	02/05/2006	30/05/2006	40.6	39.2	43.7	41	2.3	6	5.7	38	93.1	Good	Good
6	30/05/2006	27/06/2006	38.7	33.2	37.1	36	2.8	8	7.0	35	95.3	Good	Good
7	27/06/2006	01/08/2006	39.3	39.6	42.9	41	2.0	5	5.0	38	56.6	Good	Poor Data Capture
8	01/08/2006	29/08/2006	36.5	34.7	38.4	37	1.9	5	4.6	35	45	Good	Poor Data Capture
9	29/08/2006	03/10/2006	42.6	41.5	44.4	43	1.5	3	3.6	37	96.3	Good	Good
10	03/10/2006	31/10/2006	43.0	43.6	44.8	44	0.9	2	2.3	43	79	Good	Good
11	31/10/2006	28/11/2006	44.7	39.3	43.6	43	2.9	7	7.1	40	79.4	Good	Good
12	28/11/2006	03/01/2007	44.3	46.2	43.3	45	1.5	3	3.7	41.5	95.5	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

Site Name/ ID:	Dundee Whitehall St

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

(Check average CV & DC from Accuracy calculations)

Accuracy (with 95% confidence interval) without periods with CV larger than 20%

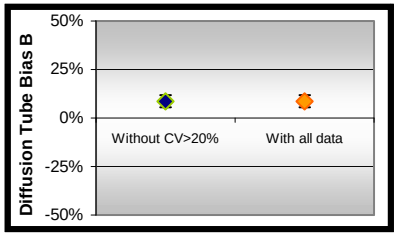
Bias calculated using 10 periods of data

Bias factor A	0.92 (0.9 - 0.95)
Bias B	8% (5% - 12%)
Diffusion Tubes Mean:	43 μgm^{-3}
Mean CV (Precision):	4
Automatic Mean:	40 μgm^{-3}
Data Capture for periods used:	92%
Adjusted Tubes Mean:	40 (39 - 41) μgm^{-3}

Accuracy (with 95% confidence interval) WITH ALL DATA

Bias calculated using 10 periods of data

Bias factor A	0.92 (0.9 - 0.95)
Bias B	8% (5% - 12%)
Diffusion Tubes Mean:	43 μgm^{-3}
Mean CV (Precision):	4
Automatic Mean:	40 μgm^{-3}
Data Capture for periods used:	92%
Adjusted Tubes Mean:	40 (39 - 41) μgm^{-3}



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