

Detailed Assessment of Air Quality in Plymouth

April 2004



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Summary

The Environment Act 1995 requires local authorities to review air quality within its area on a regular basis. New guidance was issued in 2003 detailing how the review and assessment process should be completed. The guidance specifies a two-stage approach to air quality, the first being an updating and screening assessment, which was completed in May 2003. The second stage is a detailed assessment, which aims to assess the likelihood of the objectives being exceeded for the date specified in the Technical Guidance document.

The updating and screening assessment required three pollutants to be examined in more detail, namely, nitrogen dioxide, PM₁₀ and benzene. This report examines each of the three pollutants and provides information on monitoring and some modelling, particularly of nitrogen dioxide.

Monitoring has been undertaken to investigate the levels of benzene around Holy Cross Roman Catholic School which is located within ten metres of a petrol pump at a petrol station. Although the diffusion tubes have an accuracy of +/-25%, the monitoring indicated that the objective may be at risk of being exceeded in 2010, and as the exposed population are a sensitive group, it has been decided to declare an air quality management area as a precautionary approach. Further accurate and detailed monitoring will be carried out over the next 12 months.

For nitrogen dioxide, a detailed assessment was carried out at four sites across Plymouth, which has included diffusion tube monitoring and some chemiluminescent analysis at one site. The air quality objective level for 2005 is likely to be exceeded at two of the four locations based on monitoring data, but modelling of the four locations indicated that the 2005 objective will be met. It has been decided to take a precautionary approach and declare two air quality management areas at Mutley Plain, and Exeter Street. Monitoring will continue at all four locations.

For PM₁₀, two areas required further assessment which involved the loading and unloading of dusty cargos. One site had changed the type of product stored from animal feed to ball clay, and consequently complaints have been resolved. As the lease for the storage warehouse is for 25 years, it has been decided that this does not require a detailed assessment although the situation will be kept under review.

The second site requiring a detailed assessment for PM₁₀ is Victoria Wharves, which is a commercial dock primarily loading and unloading china clay from storage areas to ships. Monitoring using a gravimetric analyser was carried out at the site, which has shown a number of exceedences of the 24-hour mean, but these are below 35 exceedences per year. However, monitoring has only been carried out for 6 months, over the winter months and it is recommended to continue monitoring for a further 12 months to obtain a more accurate picture of the number of exceedences which occur. The annual mean figure monitored to date is below the air quality objective of 40µg/m³.

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Nomenclature

µg/m ³	micrograms per metre cubed
NO ₂	nitrogen dioxide
PM ₁₀	particles of less than 10 microns in size
AAQUIRE	Air quality modelling package
AADT	annual average daily traffic

1.0 Introduction

The Environment Act was introduced in 1995, and established the statutory provisions for local air quality management for the first time in the UK. This implemented the UK National Air Quality Strategy.

Part IV of the Environment Act 1995 requires each local authority periodically to review air quality in its area. The Air Quality Regulations 1997 were introduced in December 1997 and later revised in January 2000. In addition to the objectives set out in the Air Quality Regulations 2000, and the Air Quality (Amendment) Regulations 2002 ('the Regulations'), the EU has set limit values in respect of nitrogen dioxide and benzene, to be achieved by 2010, as well as indicative limit values for PM₁₀, also to be achieved by 2010. Local authorities have to consider the present quality of the air in their district and that for future years. It is necessary to assess which pollutants, if any, will exceed the prescribed objectives (Table 1.1).

A timetable for the completion of the review and assessment process was provided to local authorities in the technical guidance document LAQM.TG(03), and following on from this, the updating and screening assessment for air quality within Plymouth was submitted to the Department of Food, Environment and Rural Affairs (DEFRA) in May 2003. This document indicated that a detailed assessment of certain pollutants, namely nitrogen dioxide, PM10 and benzene was required to assess if the air quality objectives would be met by the date specified within guidance. The following table specifies the objectives and the timescales, as specifies in the Air Quality Strategy.

Table 1.1: Summary of objectives of the UK Air Quality Strategy

Pollutant	Objective	Measured as	To be achieved by
Benzene	16.25 µg/m ³ (5 ppb)	Running Annual Mean	31 December 2003
1,3-Butadiene	2.25 µg/m ³ (1 ppb)	Running Annual Mean	31 December 2003
Carbon monoxide	10 mg/m ³ (10 ppm)	Running 8 Hour Mean	31 December 2003
Lead	0.5 µg/m ³	Annual Mean	31 December 2004
	0.25 µg/m ³	Annual Mean	31 December 2008
Nitrogen dioxide*	200 µg/m ³ (105 ppb) Not to be exceeded more than 18 times per year	1 Hour Mean	31 December 2005
	40 µg/m ³ (21 ppb)	Annual Mean	31 December 2005
Particles (PM₁₀)	50 µg/m ³ Not to be exceeded more than 35 times per year	24 Hour Mean	31 December 2004
	40 µg/m ³	Annual Mean	31 December 2004
Sulphur dioxide	266 µg/m ³ (100 ppb) Not to be exceeded more than 35 times per year	15 Minute Mean	31 December 2005
	350 µg/m ³ (132 ppb) Not to be exceeded more than 24 times per year	1 Hour Mean	31 December 2004
	125 µg/m ³ (47 ppb) Not to be exceeded more than 3 times per year	24 Hour Mean	31 December 2004
Notes: µg/m ³ - micrograms per cubic metre mg/m ³ - milligrams per cubic metre ppb - parts per billion ppm - parts per million * The objectives for nitrogen dioxide are provisional			

1.1 Summary of the Updating and Screening Assessment

The updating and screening assessment referred to above was the first stage in the review and assessment process. This was effectively a checklist of pollutants and potential sources in Plymouth, and it identified a need to continue to a detailed assessment for some pollutants. The technical guidance document, LAQM.TG(03) requires the detailed assessment to be submitted by April 2004.

The aim of a detailed assessment is to identify with reasonable certainty whether or not a likely exceedence of the air quality objectives will occur. The assumptions within the detailed assessment will need to be considered in depth, and the data that is collected or used, should be quality assured to a high standard.

Table 1.2 Purpose of each stage of the air quality review and assessment.

Updating and Screening Assessment	To identify those matters that have changed since the last review and assessment, which might lead to a risk of an air quality objective being exceeded	Use a checklist to identify significant changes that require further consideration
Detailed assessment	To provide an accurate assessment of the likelihood of an air quality objective being exceeded at locations with relevant exposure. This should be sufficiently detailed to allow the designation or amendment of any necessary AQMA's.	Use quality-assured monitoring and validated modelling methods to determine current and future pollutant concentrations in areas where there is a significant risk of exceeding an air quality objective.

Table 1.3: Pollutants identified during the updating and screening assessment that require a detailed assessment.

Pollutant	Updating and screening assessment	Detailed Assessment Required
Carbon monoxide	√	×
Benzene	√	√
1,3-butadiene	√	×
Lead	√	×
Nitrogen dioxide	√	√
Sulphur dioxide	√	×
PM10	√	√

The updating and screening assessment results as shown in Table 1.3 above, indicated several areas which had potential exceedences of the air quality objectives.

- For nitrogen dioxide, four traffic routes were identified that needed closer monitoring to determine if the air quality objective would be exceeded.
- For benzene, closer examination of one site where a petrol station with over 2 million litres of petrol per annum is located approximately ten metres away from a school
- For PM10, two locations were identified where loading of dusty cargoes occurred, resulting in complaints of dust to the local authority.

In addition, other monitoring is carried out to comply with the requirements of the detailed assessment, and although this will be discussed in detail in the later chapters, in brief, it includes diffusion tube monitoring, a Partisol for PM10 monitoring and benzene diffusion tube monitoring.

Quality Assurance and Quality Control (QA/QC) measures are detailed in Appendix 1 for both all monitoring undertaken.

1.2 Consultation

A Consultation exercise was carried out at the air quality focus group meeting which is part of the Devon Chief Officers Environmental Protection Sub Group. Regular meetings take place between representatives from each of the local authorities within Devon to discuss issues that affected neighbouring authorities, with regard to air quality, including new or substantially changed industrial processes.

2.0 Detailed Assessment of Benzene

Pollutant	Objective	Measured as	To be achieved by
Benzene	16.25 µg/m ³ (5 ppb)	Running Annual Mean	31 December 2003
Benzene	5µg/m ³	Annual Mean	31 December 2010

2.1 Results and Conclusions from the Updating and Screening Assessment

Conclusions

All the potential sources of benzene have been examined as required in LAQM.TG(03). Monitoring data provided at the AUN site in Plymouth indicated concentrations of benzene to be well below the objective level.

In addition, the two petrol storage terminals have been examined and reference made to the nomograms detailed in LAQM.TG(03). It is not necessary to proceed further with this as the petrol storage terminals are not considered to be a significant source of benzene due to their emissions.

However, it is necessary to proceed to a detailed assessment in one location, due to the close proximity of a school to a petrol station, situated on a busy road.

2.2 The Detailed Assessment

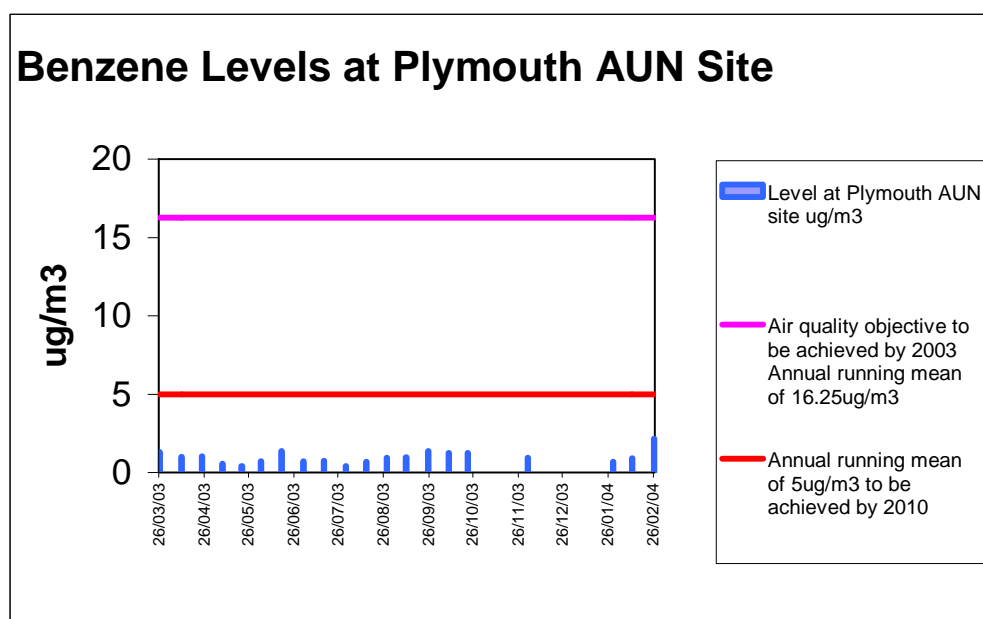
The aim of the detailed assessment is to determine with reasonable certainty whether or not there is a likelihood of the objectives for benzene being exceeded in 2010. The updating and screening assessment completed in May 2003, required further examination of the petrol station emissions due to the close proximity of the school to the petrol pumps.

2.3 Monitoring of Benzene at the AUN

Monitoring is carried out at the AUN site in Plymouth using a pumped benzene sampler as part of the Hydrocarbon Network. Tubes are exposed for two weeks at a time and attached to a pump so the air flow through the tube is measured. The results are available on www.airquality.co.uk and are shown overleaf in figure 2.1.

The levels of benzene from the pumped benzene sampler at the AUN site in Plymouth are shown in Figure 2.1 below. These levels are well below both the 2003 and 2010 objectives. The missing data occurred as a result of water ingress to the pumped sampler, and this fault has now been corrected.

Figure 2.1 Monitoring results for the pumped benzene sampler at the AUN site in Plymouth.



A co-location exercise has been carried out at the AUN site using a diffusion tube provided by Gradko. This was carried out in order to attempt to validate the results obtained from the diffusion tube monitoring carried out at Holy Cross School, as detailed in section 2.4. The Gradko tubes have an uptake rate of 1.28 nanograms per part per million per minute. They use the thermal desorption, using Chromosorb 106, and are analysed by gas chromatography. Each month WASP results are sent to the laboratory, and are available on request.

The co-location exercise has only been carried out for a period of four months at the AUN. In addition, the benzene diffusion tube at the AUN has not been exposed for the same time period as the Hydrocarbon Network tube, as these are exposed two weekly, and the other monitoring tubes are exposed four weekly, not covering the same exposure period exactly. In a discussion with the Monitoring Help Desk, it was suggested that the tubes are exposed to cover the same time periods in future to ensure an accurate co-location exercise.

The exposure of a blank tube each month is useful in determining the correct concentration of the tubes. If the blank is analysed and records a concentration, this result is then subtracted from the results to provide a more accurate figure. However, a blank tube has not been exposed with the monthly monitoring, but this will be done in the future. The Monitoring Help Desk advised that with the absorbent material used for the benzene diffusion tubes, which is Chromasorb 106, the blank for each tube could allow for a reduction in the concentration of benzene of $2.5\mu\text{g}/\text{m}^3$ when the tubes are new, decreasing to $0.5\mu\text{g}/\text{m}^3$ after each desorption/conditioning cycle. This effectively means that the blank concentration of the tube will be variable dependant on the age of the tube.

All of the co-location exercise results were sent to the Monitoring Help Desk for their advice and following an e-mail from Brian Jones from NETCEN, who deals with benzene from petrol stations, it appears that the benzene tubes co-located at the AUN are over-reading from approximately 0.4 to $1.7\mu\text{g}/\text{m}^3$. Copies of the e-mails and the set of results examining the co-location exercise are provided in Appendix 2.

Table 2.1 Results of the co-location monitoring exercise at the AUN Hydrocarbon Monitoring site.

Date of exposure of Pumped tube at AUN	Result in $\mu\text{g}/\text{m}^3$
17.1.03-02.12.03	0.94
14.01.04-29.01.04	0.68
29.01.04-11.02.04	0.91
11.02.04 - 26.02.04	2.15 Provisional
26.02.04-11.03.04	2.08 Provisional

Date of exposure of co-location tube	Result in $\mu\text{g}/\text{m}^3$
25.11.03-23.12.03	2.74
23.12.03-20.01.04	2.95
20.01.04-17.02.04	1.15
17.02.04-16.03.04	1.33

2.4 Exeter Street Petrol Station

Exeter Street petrol station is a busy site, with approximately 3 million litres of petrol throughput per annum. It is situated on the side of a busy road with 52972 vehicles AADT, using four lanes of mainstream traffic with an additional two bus lanes. The petrol station is also situated next to traffic lights at a junction.

The site is bound on three sides by taller buildings, and has a canopy over the station. A primary school is located within 10 metres of the pumps, with the building façade directly adjoining the boundary in some locations. There is a high retaining wall, and the school is at a much higher level than the petrol station. Directly over the wall from the petrol vents is the school playground.

The photograph in Figure 2.2 demonstrates the proximity of the school to the petrol station, as the school can be seen above the retaining wall at the back of the petrol station.

Figure 2.2 Photograph to show the location of the school, behind the retaining wall to the rear of the petrol station.



2.4.1 Monitoring at Exeter Street Petrol Station

Due to financial restrictions, it was decided to commence a monitoring programme using diffusion tubes. The technical guidance document LAQM.TG(03) suggested that diffusion tube accuracy for benzene monitoring is +/-25%. However, a sampling strategy was discussed with the Monitoring Helpdesk, including the co-location of a tube with the Hydrocarbon Network Site. This is explained in more detail in section 2.3.

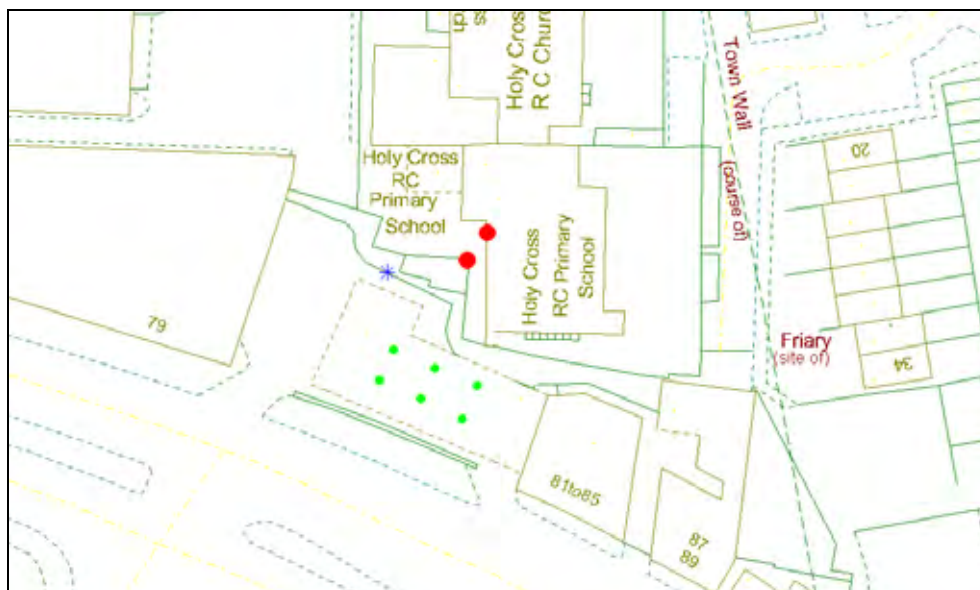
The monitoring location of the diffusion tubes at the school has presented some difficulties due to the shape of the school building. LAQM.TG(03) guidance suggests that to monitor for an annual mean, which is the 2010 objective, then the objectives would apply at a building façade of a school or residential property. It was decided that monitoring should be carried out in the playground area, and the wall of the school playground was chosen as the location to represent relevant exposure. This can be demonstrated in Figure 2.2 above, where the tube is located at the top of the wall above the car.

Figure 2.3 Photograph to show the two monitoring locations at Holy Cross School.



Eight months of monitoring data has been obtained at the location on the school wall directly overlooking the vents. This can be seen in the above photograph, directly below the down pipe on the top of the boundary wall. In addition to this, four months of monitoring has been undertaken at the school doorway, which is further from the vents and is located directly above the blue door. In addition, there has been four months of co-location with the AUN. Figure 2.4 shows the location of the school and of the petrol station. The red dots represent the diffusion tubes that have been placed at the school.

Figure 2.4 Map to show the location of the petrol station and the school, including the location of the monitoring points.



Blue star represents the vents for the petrol station
 Red dots represent the location of the diffusion tubes
 Green dots represent the petrol pumps

Figure 2.5 shows the results from the monitoring undertaken at the school compared to the 2010 objectives. With only eight months of monitoring, the running annual mean figure of $4.996\mu\text{g}/\text{m}^3$ has been obtained, although the objective is an annual mean, not a running annual mean. However, when this is compared against the accuracy figure of plus or minus 25%, the figure may be either $6.2456\mu\text{g}/\text{m}^3$ if the tubes under-read and $3.7474\mu\text{g}/\text{m}^3$ if they over read.

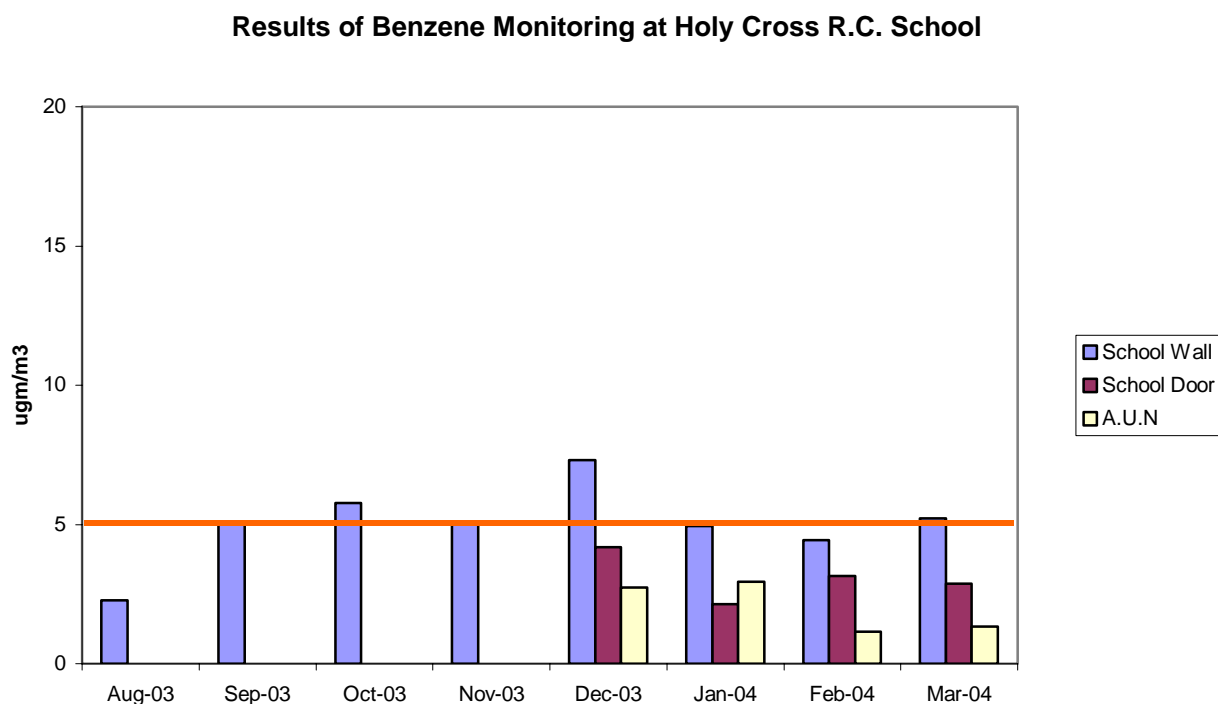
If an annual mean figure is taken for 2003 using only the 5 months of monitoring data for that time period, a forecast figure can be obtained for 2010, by using Box 3.3 in LAQM.TG(03), which is shown in Table 2.2. However, it is not recommended that this is undertaken for industrial sources unless abatement technology is expected to reduce the concentrations. However, LAQM.TG(03) indicated that there is no legal requirement to fit Stage 2 vapour recovery, and as a result it is not expected that the emissions will be reduced by abatement technology. Therefore the results from Table 2.2 must be observed with caution.

Table 2.2 Estimated concentrations of benzene for 2010, using the 2003 annual mean figure.

Location	Annual mean figure for 2003 in $\mu\text{g}/\text{m}^3$	Estimated 2010 $\mu\text{g}/\text{m}^3$
School wall	5.074	3.34

The forecast for 2010 is $3.34\mu\text{g}/\text{m}^3$, which is well below the 2010 objective figure, as can be seen in Table 2.2. However, this must be viewed with caution as there is no legal requirement to fit stage 2 vapour recovery.

Figure 2.5 Results of actual benzene diffusion tube monitoring at Holy Cross School in $\mu\text{g}/\text{m}^3$



2.5 Discussion of results

The monitoring results for Exeter Street Petrol Station are a cause for concern, primarily as the young children at the school could potentially be exposed to concentrations of benzene in excess of $5\mu\text{g}/\text{m}^3$. However, the diffusion tube monitoring results can be seen as only an indication as their accuracy could be $\pm 25\%$. The raw data indicated that from the 8 months monitoring undertaken so far, the mean figure of these results is $4.996\mu\text{g}/\text{m}^3$. When this figure is rounded up, it is at the 2010 objective level. In addition, following a discussion with Brian Jones, at NETCEN, it was indicated that the results in the winter months may be lower, due to higher winds and possibly would increase in summer due to lower wind speeds.

When these results are forecast to 2010, as shown Table 2.2 from LAQM.TG(03), the concentrations are predicted to fall well within the 2010 figure, but this table is intended to show lower concentrations following the retrofitting of abatement technology.

It has been advised following a discussion with the Monitoring Help Desk, that the diffusion tubes are over-reading when the existing co-location data was examined by approximately 0.4 to $1.7\mu\text{g}/\text{m}^3$, meaning that the actual results from the Petrol Station would be lower. Details of this are provided in Appendix 2. However, a co-location exercise at the AUN will continue to attempt to validate the results taken from the school.

It is further recommended that more extensive monitoring at the school is undertaken to accurately examine the concentrations experienced within the school grounds

2.6 Conclusions

Bearing all of the above factors in mind, it has been decided to declare an Air Quality Management Area, due to the sensitivity of the exposed population. The monthly results from Exeter Street petrol station do cause concern, primarily as the young children at the school could potentially be exposed to concentrations of benzene in excess of $5\mu\text{g}/\text{m}^3$. Plymouth City Council are satisfied that there is a likelihood of the 2010 objective of $5\mu\text{g}/\text{m}^3$ not being met, as there are no plans to install Stage 2 vapour recovery at the present time. In addition, due to the monitoring being carried out over the winter months, higher concentrations could be

expected during the summer months when wind speeds are expected to be lower and there is less dispersion of benzene.

The diffusion tube monitoring however has an accuracy of +/- 25%, which could mean the results are under or over $5\mu\text{g}/\text{m}^3$.

When the five months of results taken at the school in 2003 are forecast to 2010, using the calculation suggested in LAQM.TG(03) they are expected to meet the 2010 objective, however, there are no plans to install stage 2 vapour recovery at this time. This result should be viewed with caution and is not relevant should abatement technology not be fitted.

Further detailed monitoring will be required to provide a more accurate picture of the concentrations of benzene in the vicinity of the school.

3.0 Detailed Assessment of Nitrogen Dioxide

Pollutant	Objective	Measured as	To be achieved by
Nitrogen dioxide	200 µg/m ³ (105 ppb) Not to be exceeded more than 18 times per year	1 Hour Mean	31 December 2005
	40 µg/m ³ (21 ppb)	Annual Mean	31 December 2005

3.1 Results and Conclusions from the Updating and Screening Assessment

Conclusion

The checklist has been followed for all potential sources of NO₂. There is a need to proceed to a detailed assessment for NO₂ based on the monitoring data only.

Monitoring has been carried out using diffusion tubes at different locations around the city at some roadside and some relevant exposure locations.

By forecasting the predicted concentrations of NO₂, at some of these locations after the results have been bias adjusted, it has indicated that there may possibly be an exceedence of 40µg/m³ in 2005.

As a result, it is necessary to proceed to a detailed assessment for Embankment Road, Exeter Street, Mutley Plain and Plymouth Road.

3.2 The Detailed Assessment

Four sites were identified from the updating and screening assessment that required a detailed assessment to assess the likelihood of the objectives not being achieved. This was based on monitoring data from diffusion tubes, exposed at both relevant locations and non-relevant locations for public exposure. Table 1.1 is taken from the updating and screening assessment report, showing the estimated 2005 and 2010 annual mean values using bias adjusted diffusion tube data.

Table 3.1 Estimated 2005 and 2010 annual mean values using bias adjusted diffusion tube data from 2002.

Road	Bias adjusted 0.82			Bias adjusted 0.86		
	2002	2005	2010	2002	2005	2010
Embankment Road	42.4	39.04	32.12	44.48	40.94	31.01
Portokabin*						
Exeter Street	41.01	37.75	31.06	43.01	39.59	29.99
Mutley Plain*	47.12	43.37	35.69	49.42	45.49	34.46
Plymouth Road*	41.23	37.95	31.23	43.24	39.8	30.15

*denotes roadside monitoring site.

Source: Updating and Screening Assessment 2003

In the detailed assessment of each site, diffusion tubes have been installed in relevant locations for public exposure to enable a more accurate assessment of the likelihood of the objectives being exceeded. Detailed maps showing the location of the tubes are shown in the following sections for each monitoring location.

The detailed assessment has included monitoring, and forward forecasting using Tables from LAQM.TG(03), and the use of a modelling package to determine the likelihood of the objectives for NO₂ being exceeded in 2005.

3.3 Monitoring of NO₂ at the AUN site.

As Plymouth is part of the national air quality monitoring network, with an AUN site at an urban background location, it has been possible to conduct a co-location exercise, using triplicate diffusion tubes to obtain a relevant bias adjustment factor.

The diffusion tubes have been supplied and analysed by Gradko, using the 20% TEA in water tube preparation method. QA/QC details are provided in Appendix 1.

Data from the AUN is ratified by NETCEN on a six monthly basis. Both ratified and unratified data has been used in the production of a bias adjustment factor, but caution has been exercised in analysing the unratified data. A number of different scenarios have been considered when calculating the bias factor. The bias adjustment factor has been calculated following Box 6.4 in the Technical Guidance document LAQM.TG(03). The results of this calculation can be seen in Table 3.2 below.

The 2003 bias adjustment factor has been calculated using the co-location exercise in 2003, but due to there being several months where there has been less than 90% data capture at the AUN, a second bias adjustment factor has been calculated using some unratified data to provide an alternative figure.

QA/QC procedures for both the AUN site and diffusion tube monitoring is detailed in Appendix 1.

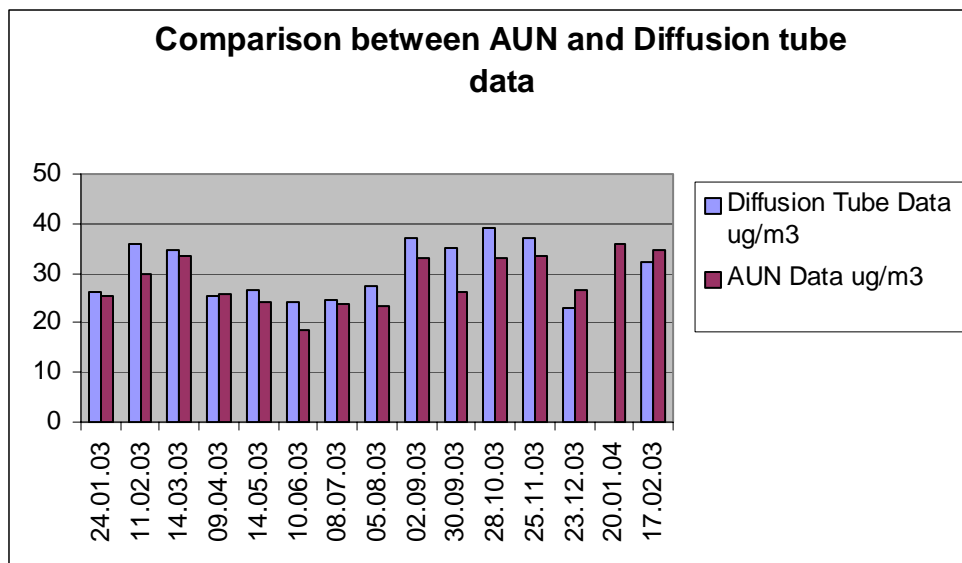
Table 3.2 shows the results of the co-location exercise with triplicate NO₂ diffusion tube results compared to the chemiluminescent results from the AUN site for the same time period. Table 3.2 Result of the co-located NO₂ diffusion tube compared to the monthly continuous results.

BIAS ADJUSTMENT FACTOR FOR NO2 TUBES								
Date Out	Date in	AUN1	AUN2	AUN3	Average AUN		AUN Chem	
24/01/2003	11/02/2003	22.25	27.59	29.37	26.40		25.31	R
11/02/2003	14/03/2003	35.66	34.58	37.28	35.84		29.93	R ◀
14/03/2003	09/04/2003	32.31	36.04	36.04	34.80		33.65	R ◀
09/04/2003	14/05/2003	23.91	24.83	27.58	25.44		25.61	R
14/05/2003	10/06/2003	25.85	25.85	27.58	26.43		24.07	R
10/06/2003	08/07/2003	21.89	28.8	21.31	24.00		18.57	R ◀
08/07/2003	05/08/2003	25.42	24.84	23.11	24.46		23.70	R ◀
05/08/2003	02/09/2003	26.00	27.73	28.31	27.35		23.37	R
02/09/2003	30/09/2003	36.98	35.82	38.13	36.98		33.00	R
30/09/2003	28/10/2003	32.93	34.67	37.55	35.05		26.32	R
28/10/2003	25/11/2003	39.86	40.44	36.98	39.09		32.90	R
25/11/2003	23/12/2003	35.98	37.1	37.66	36.91		33.52	R
23/12/2003	20/01/2004	22.54	23.67	22.94	23.05		26.60	p ◀
20/01/2004	17/02/2004						35.81	p ◀
17/02/2004	16/03/2004	34.67	29.47	32.93	32.36		34.85	p
Bias Adjustment Factor (all data)								
					Dm	30.58	Cm	28.48
Bias adjustment factor A:					0.93			
Diffusion tube bias factor B:					0.07 Diff tubes over read by 7%			
Bias Adjustment Factor (without prov data and less than 90% data capture)								
					Dm	31.71	Cm	28.01
Bias adjustment factor A: (2003 bias)					0.88			

Bias Adjustment Factor (without less than 90% data capture)				
	Dm	31.78	Cm	28.77
Bias adjustment factor A:		0.91		
All values in ug/m3				
R = Ratified data		P = Provisional data	◀ = Less than 90% data for those dates	

AUN1, 2 and 3 represent the diffusion tubes located at the AUN
AUN Chem represents the continuous monitoring at the AUN

Figure 3.1 Comparison of AUN data and diffusion tube data from the co-location exercise at the AUN



The two relevant bias adjustment factors are 0.88 using only ratified data, providing the bias factor for 2003 and 0.91 with both ratified and unrated data, with both sets of results excluding the data with less than 90% data capture. These factors are further expanded in Table 3.2 above.

Both of these factors have been applied across all the diffusion tube data for the last year, at all monitoring sites and the table containing this information is included in Appendix 3.

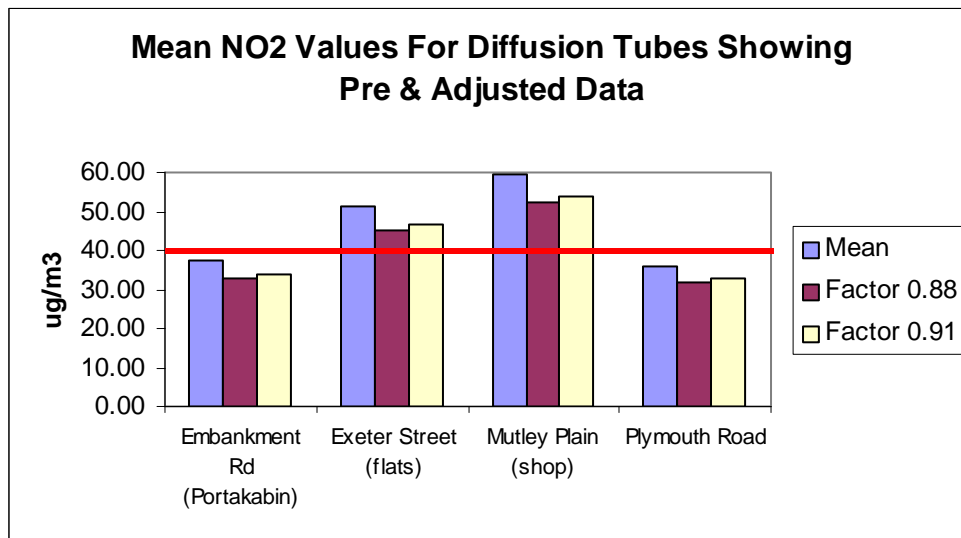
The results from the four locations requiring a detailed assessment are shown in Table 3.3 below.

Table 3.3 Results of the annual mean diffusion tube monitoring using bias adjustment factors.

Location	Mean	Factor 0.88	Factor 0.91
Embankment Rd (Portokabin)	37.75	32.22	34.35
Exeter Street (flats)	52.03	45.42	47.35
Mutley Plain (shop)	59.90	52.71	54.51
Plymouth Road	35.64	31.36	32.43

The results from Table 3.3 are discussed in the relevant section for each site.

Figure 3.2 Graph to show the raw data and bias adjusted data for the 4 sites requiring a detailed assessment.



3.4 Mutley Plain

Mutley Plain is a major arterial route in to the city, containing four lanes of traffic, with several sets of traffic lights. This results in a considerable amount of slow moving traffic. In addition to this, it is a relatively busy shopping area, containing a mixture of small shops, bars and pubs. On each side of the road is a pavement of approximately four metres, with tall buildings on either side, of approximately four storeys. The route also has a considerable amount of buses, with no dedicated bus lane.

Figure 3.3 is a photograph of Mutley Plain showing the row of shops where monitoring is carried out.



3.4.1 Monitoring Results

Continuous monitoring

Due to financial constraints, it was decided to purchase one continuous analyser to monitor for NO₂. As a result, it was decided to install this in to a first floor room of a shop premises on Mutley Plain as this was the location with the highest results from the diffusion tube monitoring, although the initial diffusion tube results were from a roadside location, and not representing relevant exposure.

The shop was chosen as there was a store-room area that the equipment could be installed in to, and although no one lived at this address, other first floor properties in the street are occupied as dwellings, thus representing relevant exposure for an annual mean objective.

A continuous chemiluminescent analyser, provided by Casella ETi was installed in to the shop in December 2003, following several problems with delivery and installation from the supplier. The intake was taken outside of the window, and attached to a rainwater pipe, and is located side by side with the diffusion tube, indicating a good co-location site. Due to the late installation date, it has been impossible to carry out a full 12 months of monitoring and consequently, the results alone cannot provide certainty that the annual objectives for NO₂ will be exceeded.

The results from the continuous analyser are shown in Table 3.4 and each month the results are above the objective figure. Details of the QA/QC for the monitor are shown in Appendix 1. Table 3.4 Monthly mean monitoring results from the chemiluminescent monitor at Mutley Plain.

Month	Monthly mean in µg/m ³
Jan 04	40.36
Feb 04	43.89
March 04	47.96

Diffusion Tube Monitoring

Table 3.1 above refers to the results from the diffusion tube monitoring completed as part of the updating and screening assessment. When these are bias adjusted, using the factors calculated and shown in Table 3.3, it indicates that the annual mean figure is above the objective for 2005. The more recent results are shown in Table 3.5 for monitoring at a relevant exposure location since May 2003.

Figure 3.4 Map to show the location of the diffusion tube at Mutley Plain to represent relevant exposure.



Table 3.5 Monthly diffusion tube results for Mutley Plain

Mutley Plain	Raw data	Adjusted data 0.88
May	62.05	54.60
June	59.91	52.72
July	51.42	45.25
August	57.20	50.34
September	69.91	61.52
October	57.20	50.34
November	66.44	58.47
December	55.09	48.48
2003 mean figure	59.90	52.71
January	40.42	35.57
February	73.47	64.65
Mean	59.31	52.80

When the 2003 mean figure is used to forecast the 2005 and 2010 results using Box 6.6 from LAQM.TG(03), the results for 2005 still indicate an exceedence of the 2005 objective of $40\mu\text{g}/\text{m}^3$, with the predictions for 2010 still being above the 2010 objective.

Table 3.6 Estimate of the annual mean figure for 2005 and 2010, for monitoring data from Mutley Plain, in $\mu\text{g}/\text{m}^3$

	Actual 2003 mean result	Bias adjusted 2003 result	Estimated 2005	Estimated 2010
Mutley Plain	59.90	52.71	49.97	41.11

When the continuous monitoring result is compared to the diffusion tubes for the same exposure period, the results are shown in Table 3.6 below.

Table 3.7 Comparison of continuous monitoring and diffusion tube monitoring results at Mutley Plain.

Dates of exposure of the diffusion tubes.	Diffusion tube result $\mu\text{g}/\text{m}^3$	Chemiluminescent result $\mu\text{g}/\text{m}^3$
23.12.03-20.01.04	35.56	35.11
20.01.04-17.02.04	64.65	44.67
17.02.04-16.03.04	50.84	50.75

These results show good correlation for two time periods, with the data for January showing a poorer correlation. The data from the continuous analyser has been examined and any anomalies taken out. QA/QC details are provided in Appendix 1.

3.4.2 Modelling Results for Mutley Plain.

Plymouth City Council, along with two other neighbouring local authorities purchased the AAQUIRE modelling package from CES, now known as Faber Maunsell.

The most recent version of the AAQUIRE Regional Air Quality Model from 2003 was used to undertake modelling for the detailed assessment. AAQUIRE uses dispersion algorithms based on the CALINE4 system for modelling road traffic. The model has been widely validated and used throughout the world (AAQUIRE manual 2000; 2003). The version of AAQUIRE used incorporated the latest emissions factors database for the UK. The meteorological data used was from Plymouth Airport meteorological station and was for the year 1995. This is older than is recommended in the Technical Guidance (LAQM. TG(03)), but is the most recent comprehensive data available from Plymouth (the next nearest from which suitable data are available being Yeovilton in Somerset.) The 1995 Plymouth meteorological data has previously been examined by CES and been deemed to be the most typical of meteorological data over 5 years.

The CALINE 4 model used incorporates default factors for the conversion of NO_x to NO₂ and these default factors were used in the modelling exercises.

In addition to the integral model data, further data relating to vehicle composition, speed, geographical factors and background NO₂ concentrations were input to the model and are shown in tables within the sections for each location. Vehicle counts were based on data provided by the Transport Section of Plymouth City Council, from October 2003 which is seen to represent the most accurate month.

The total vehicle counts for future years were extrapolated forward using an estimated total traffic growth rate of 1% per year. It is likely to be an overestimate for years beyond this as national data show traffic growth slowing (DETR, 1999), but is useful for providing a worst-case screening.

The proportion of HGVs for each road has been taken from the Automatic Traffic Count data, but Plymouth Road did not have any available data. As a result, a similar figure from the other sites used, although this is likely to be a higher figure, due to Plympton being a more residential area.

AAQUIRE requires a further breakdown of vehicle categories according to whether engines are petrol or diesel, and, if petrol, fitted with a catalyst or not. Proportions for this were calculated by extrapolating the proportions given in the National Atmospheric Emissions Inventory traffic projections (from www.naei.org.uk) and slightly increasing the proportion without catalysts for future years – again to provide a worst case scenario and to reflect the assumed slightly older average age of cars in Devon compared to the national fleet.

Proportions of hot and cold engines were estimated – assuming a worst-case situation with a large number of colder engines. Average speed data was provided by the Transport section for two roads and estimated for two roads based on experience of travelling frequently on the road at all times of the day.

Data relating to the road dimensions were obtained by measuring road width on the Geographical Processing system (GGP) used by the Council. The right and left mix widths of the road were designated as zero which indicates no significant dispersion of pollutants, although Exeter Street for example is a wide road with open spaces on either side. However, worst case scenario was used in all cases.

Background pollution levels were obtained from the grid square information given by the NAEI on www.naei.org.uk and these were extrapolated to future years as required according to the guidance given in LAQM.(TG03).

Details on model validation are provided in section 3.8.

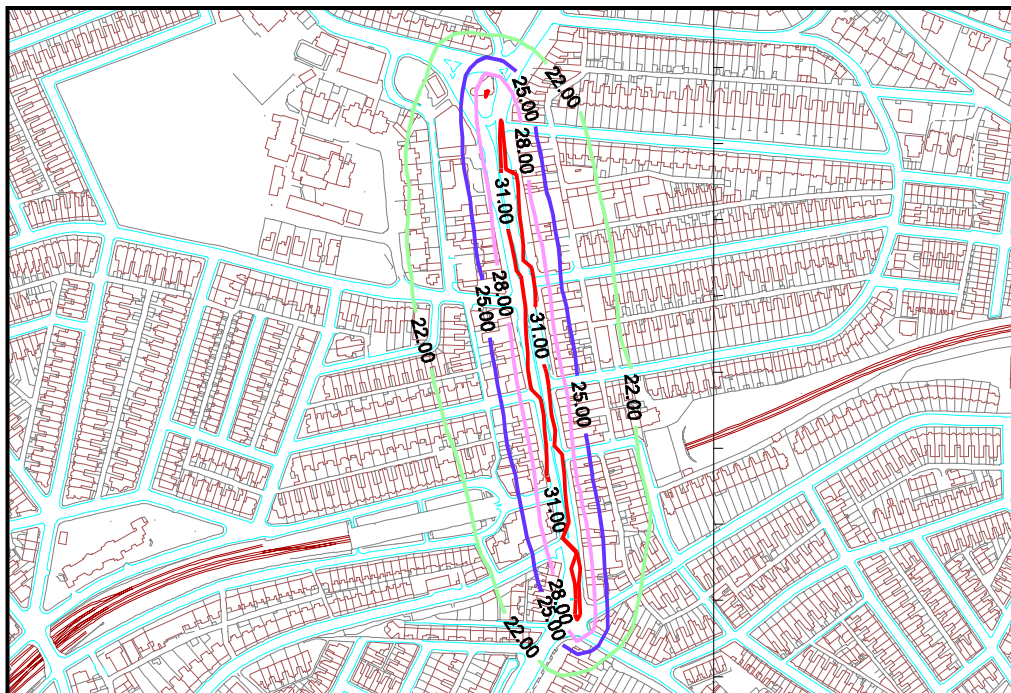
Table 3.8 Input data for AAQUIRE for modelling of Mutley Plain, 2005.

DATA INPUT	Mutley Plain
Surface roughness	Large town/city
Class	1
Area modelled: SW grid point	248000 55500
Area modelled; NE grid point	248500 56000
Grid space	15
Receptor height	1.5
Year	2005
Road coordinates	248412 55567 248348 55949
Vehicles per hour 2005	2618
% HDV	5.1
Average speed km/hr	20
Road height	0
Road width	16.81

Road type	1 (flat)
Left mix width	0
Right mix width	0
% LDV petrol cold	4
%LDV petrol hot	6
% LDV petrol cold catalyst	25
% LDV petrol hot catalyst	40
% LDV diesel cold	5
% LDV diesel hot	20
% HGV cold	30
% HGV hot	70
Background conc.NOx (ug/m3)	28.65
Default Nox/NO ₂ ratios applied.	Yes
Met data	Plymouth

The modelling predictions using AAQUIRE calculate that the concentrations of NO₂ in 2005 will be significantly below the 40µg/m³ objective, with the highest recorded concentration for 2005 being 32.76µg/m³. However, it appears from the validation exercise undertaken, that the model is under-estimating the predicted concentrations significantly, which it appears to have done for the busier more congested results, such as this site and Exeter Street. A validation exercise has been undertaken and this is shown in section 3.8. Two of the sites modelled appear to give a reasonable estimate of the expected concentrations, whereas the two more congested routes appear to significantly under-estimate.

Figure 3.5 Contour map to show the concentrations of NO₂ in Mutley Plain



3.4.3 Conclusion of the Detailed Assessment for Mutley Plain

The diffusion tube results indicate that there is an exceedence of the objective for NO₂ based on monitoring data for 2003, when the data is bias adjusted and forecast for 2005. This is shown in Table 3.4. Even the forecast for 2010 is above the 2010 objective.

In addition, the monitoring data from the chemiluminescent monitor has only been in operation for 4 months and this has concurred with the diffusion tube data, which can be seen in Table 3.6. However, the modelling data suggests that the highest figure expected in 2005 in the centre of the road would only be 32.76µg/m³, which does not concur with the monitoring information. It appears that in the more congested routes, the model significantly under-reads the concentrations of NO₂.

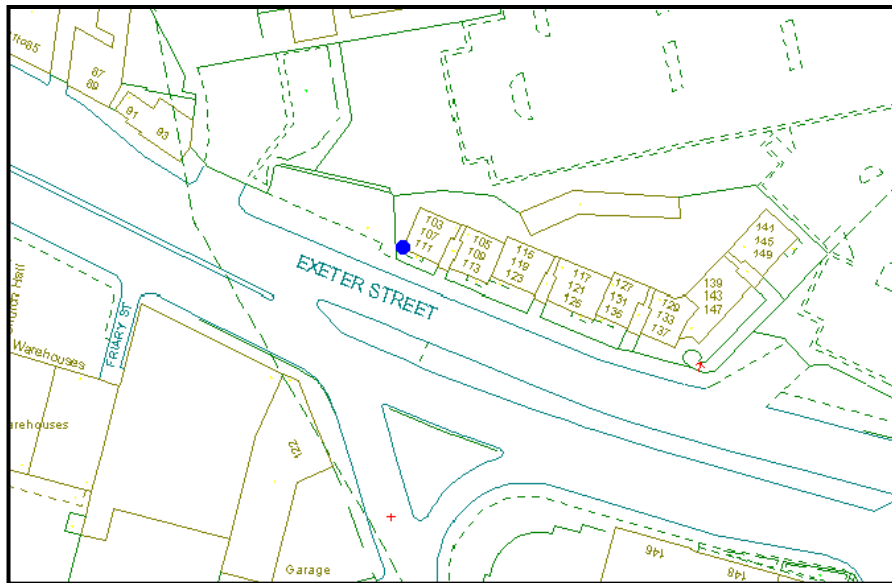
3.5 Exeter Street

Exeter Street is another major route in to the city centre, with the majority of the city-bound traffic from Devon and the north using this route. The road consists of six lanes, three on either side, one on either side of which is a dedicated bus lane. There are three sets of traffic lights, and the road has slow moving traffic during rush hour. The road has a fairly open outlook, with a three-storey block of council owned flats within approximately 5 metres of the roadside. The flats have small balconies on the upper levels, and no garden area at the front for residents to sit outside.

Figure 3.6 Photograph to show the flats on Exeter Street



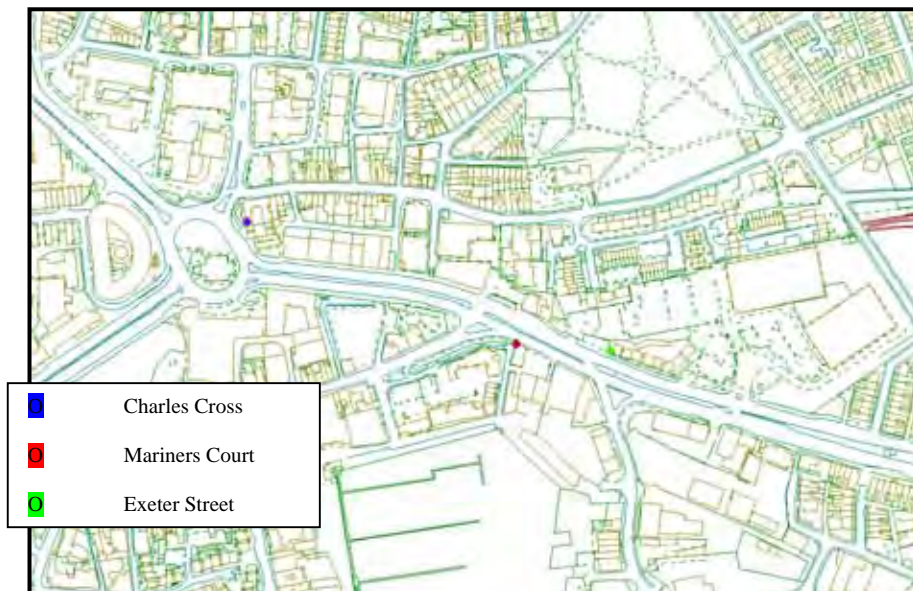
Figure 3.7 Map to show the location of the diffusion tube on Exeter Street, to represent relevant exposure.



3.5.1 Monitoring Results

Due to financial constraints, only diffusion tube monitoring has been undertaken at this site. A diffusion tube has been located at the ground floor level near to an openable window, situated on a rain water down pipe on a block of flats that represents worst case exposure. This is on the building façade, so represents relevant exposure for an annual mean exposure, as shown in Figure 3.7 above.

Figure 3.8 Map to show all the monitoring locations on Exeter Street



Other diffusion tube monitoring has been undertaken at sites shown in Figure 3.5, to represent other relevant exposures which are situated along the road to examine the size of any proposed AQMA.

The results from the diffusion tube monitoring is shown in Table 3.9 below, giving figures for the raw data, and after the results have been adjusted using 0.88, the figure taken from section 3.3 above.

Table 3.9 Monthly diffusion tube results from Exeter Street, which are bias adjusted using the 2003 annual mean figure in $\mu\text{g}/\text{m}^3$

Exeter Street	Raw results	Bias adjusted
Feb 03	53.48	47.06
March	51.57	45.38
April	49.65	43.69
May	49.41	43.48
June	54.15	47.65
July	44.49	39.15
August	52.58	46.27
September	57.78	50.84
October	56.62	49.83
November	52.00	45.76
December	50.59	40.52
Annual mean 2003	52.03	45.42
January	34.18	30.08
February	60.19	48.20
MEAN	51.28	44.45

When the 2003 mean diffusion tube figures are used to forecast the 2005 and 2010 results using Box 6.6 from LAQM.TG(03), the results for 2005 still indicate an exceedence of the 2005 objective of $40\mu\text{g}/\text{m}^3$, with the predictions for 2010 being under the 2010 objective.

Table 3.10 Estimate of the annual mean figure for 2005 and 2010, using Box 6.6 for monitoring data from roadside sites.

	Actual 2003 mean result	Bias adjusted 2003 result	Estimated 2005	Estimated 2010
Exeter Street	52.03	45.42	43.04	35.43

Some additional diffusion tube monitoring has been undertaken at several locations close to Exeter Street in an attempt to discover the extent of the proposed AQMA. Monitoring has been undertaken using diffusion tubes, but this has only continued for 10 months. It appears that the results of the monitoring show a potential exceedence of the $40\mu\text{g}/\text{m}^3$ at Charles Cross roundabout

The locations of the monitoring sites are shown in Figure 3.5.

The results for the monitoring are shown in Table 3.11, including the bias adjusted figure, using the calculated bias for 2003.

Table 3.11 Monthly mean values from diffusion tube monitoring around Exeter Street

Month	Charles Cross Raw data	Charles cross adjusted figure	Mariners Court Raw data	Mariners Court Adjusted figure
May 2003	45.39	39.94	41.94	36.90
June	36.29	31.93	42.63	37.51
July	40.44	35.59	37.55	33.04
August	49.11	43.22	43.33	38.13

September	58.93	51.86	48.53	42.70
October	57.20	50.34	43.33	38.13
November	52.00	45.76	41.60	36.61
December	47.78	42.05	39.91	35.12
2003 Mean	48.40	42.55	42.35	37.27
January 2004	33.11	29.14	34.74	30.57
February	59.52	52.38	53.40	46.99
Mean of all data	47.98	42.22	42.70	37.57

When the 2003 results are forecast for 2005 and 2010 using Box 6.6 from LAQM.TG(03), the results show that the Charles Cross location is predicted to be very slightly above $40\mu\text{g}/\text{m}^3$ and the Mariners Court site is predicted to be below $40\mu\text{g}/\text{m}^3$. These are shown in Table 3.12 below.

Table 3.12 Results of the forecast for Charles Cross and Mariners Court for 2005 and 2010.

Site	Actual Mean result for 2003	Bias adjusted 2003 result	Estimated 2005	Estimated 2010
Charles Cross	48.40	42.55	40.33	33.19
Mariners Court	42.35	37.27	35.33	29.07

3.5.2 Modelling Results

Details of the AAQUIRE modelling package are explained in 3.4.2, along with an explanation of the input data. Model validation is provided in section 3.8.

Table 3.13 Input data for AAQUIRE for modelling of Exeter Street, 2005.

DATA INPUT	Exeter Street
Surface roughness	Large Town/ City
Class	1
Area modelled: SW grid point	248000 54500
Area modelled; NE grid point	248500 55000
Grid space	15
Receptor height	1.5
Year	2005
Road coordinates	248416 54582 248943 54419
Vehicles per hour 2005	4336
% HDV	4.8
Average speed km/hr	38
Road height	0
Road width	25
Road type	1 (flat)
Left mix width	0
Right mix width	0
% LDV petrol cold	4
%LDV petrol hot	6
% LDV petrol cold catalyst	25
% LDV petrol hot catalyst	40
% LDV diesel cold	5
% LDV diesel hot	20
% HGV cold	30
% HGV hot	70
Background conc.NOx (ug/m3)	28.65
Default Nox/NO ₂ ratios applied.	Yes
Met data	Plymouth

The modelling results indicate that the objective for 2005 will be met at all locations. The highest recorded value estimated by the model was $33.43\mu\text{g}/\text{m}^3$ and this figure represents the worst case scenario in the centre of the road.

Some work has been undertaken in an attempt to validate the model, and this is shown in section 3.8. This confirms that the model is underestimating the results, which it appears to do for busier roads.

3.5.3 Conclusion of the Detailed Assessment for Exeter Street

The monitoring results from the diffusion tubes indicate an exceedence of the air quality objective in 2003. When this is bias adjusted and forecast using the calculations based in the guidance document LAQM.TG(03), it is predicted that the $40\mu\text{g}/\text{m}^3$ will be exceeded in 2005 by about $3\mu\text{g}/\text{m}^3$. However, in 2010 it is expected that the levels of NO_2 will be lower, and will be well below the objective of $40\mu\text{g}/\text{m}^3$.

The modelling predictions using AAQUIRE however, predict that the concentrations of NO_2 in 2005 will be significantly below the $40\mu\text{g}/\text{m}^3$ objective, with the highest recorded concentration for 2005 being $33.43\mu\text{g}/\text{m}^3$. However, it appears from the validation exercise undertaken, that the model is under estimating the predicted concentrations significantly, which it appears to have done for the busier more congested results.

As a result of this monitoring data, it is the intention to declare an AQMA for Exeter Street. The extent of the AQMA has yet to be determined but some monitoring of locations surrounding relevant exposure locations has been carried out, indicating that some results are over the $40\mu\text{g}/\text{m}^3$ at some locations for the current year. When these are forecast for 2005 and 2010, one site is over, and one site is under the objective for 2005, with both sites being under the 2010 objective.

3.6 Plymouth Road

This road is in an outer suburb of Plymouth, and has 4 lanes of traffic with a central reservation containing trees and vegetation. Although there are some superstores situated on this road, the road does not have a large concentration of HGV's, as the route leads to a residential area.

3.6.1 Monitoring Results

Diffusion tube monitoring has been carried out at Plymouth Road in the garden of a residential property, situated on a rainwater down pipe on the building façade. The following map shows the exact location of the diffusion tube, representing a relevant exposure location.

Figure 3.9 Map to show the location of the diffusion tube at Plymouth Road, Plympton.



The results from the diffusion tube monitoring are shown in Table 3.14, showing that the results are consistently below the 2005 objective, apart from one month.

Table 3.14 Monthly diffusion tube results from Plymouth Road

Plymouth Road	Raw results	Bias adjusted
March 2003	34.17	30.07
April	35.86	31.56
May	37.92	33.37
June	30.53	26.87
July	31.78	27.97
August	31.78	27.97
September	38.13	33.55
October	34.67	30.51
November	43.33	38.13
December	38.23	33.64
Mean for 2003	35.64	31.36
January	30.74	27.06
February	34.67	30.51
Mean	35.15	30.93

Taking just the 2003 annual mean figure, the concentrations for future years can be estimated using Box 6.6 from the guidance LAQM.TG(03). The results in this table indicate that the 2005 and 2010 figures are well within the objective levels.

Table 3.15 Estimate of the annual mean figure for 2005 and 2010, for monitoring data from Plymouth Road, in $\mu\text{g}/\text{m}^3$.

	Actual 2003 mean result	Bias adjusted 2003 result	Estimated 2005	Estimated 2010
Plymouth Road	35.64	31.36	29.73	21.66

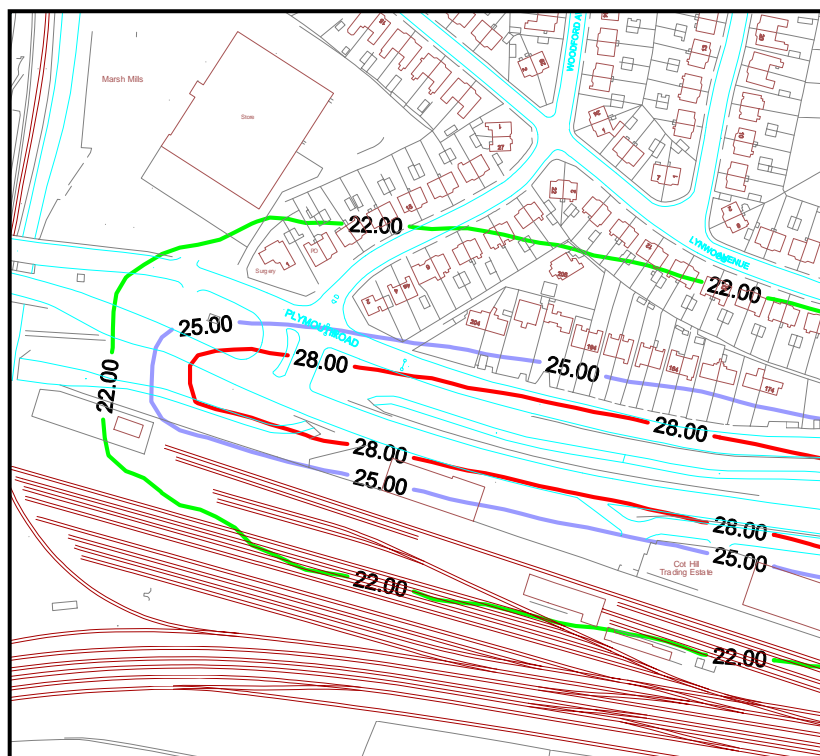
3.6.2 Modelling Results

Modelling was carried out for this location. Details of the AAQUIRE modelling package are explained in 3.4.2, along with an explanation of the input data. Model validation is provided in section 3.8.

Table 3.16 Data input to AAQUIRE for modelling of Plymouth Road, 2005.

DATA INPUT	Plymouth Road
Surface roughness	Large town/city
Class	1
Area modelled: SW grid point	252000 56500
Area modelled; NE grid point	252500 57000
Grid space	15
Receptor height	1.5
Year	2005
Road coordinates	252100 56729 252722 56597
Vehicles per hour	4471
% HDV	4.8
Average speed km/hr	40
Road height	0
Road width	43.72
Road type	1 (flat)
Left mix width	0
Right mix width	0
% LDV petrol cold	4
%LDV petrol hot	6
% LDV petrol cold catalyst	25
% LDV petrol hot catalyst	40
% LDV diesel cold	5
% LDV diesel hot	20
% HGV cold	30
% HGV hot	70
Background conc.NOx (ug/m3)	28.65
Default Nox/NO ₂ ratios applied.	Yes
Met data	Plymouth

Figure 3.10 Contour map to show the concentrations of NO₂ around Plymouth Road.



The modelling predictions using AAQUIRE however, predict that the concentrations of NO₂ in 2005 will be significantly below the 40µg/m³ objective, with the highest recorded concentration for 2005 being 30.74µg/m³. However, it appears from the validation exercise undertaken, which is shown in section 3.8 that the model at this location is providing a similar result to that obtained from the diffusion tube bias adjusted mean figure and was therefore seen to be a representative prediction.

3.6.3 Conclusions of the Detailed Assessment for Plymouth Road

The monitoring results from the diffusion tubes indicate that the air quality objective for NO₂ will be met at the Plymouth Road site. The modelling results for 2005 indicate that the highest concentration expected in the centre of the carriageway is 30.74µg/m³, which is a similar figure expected using the calculation in Box 6.6 of the LAQM.TG(03) guidance for forward forecasting of monitoring data.

Consequently as both the monitoring results and the modelling results indicate that the 2005 and 2010 objectives for NO₂ will be met there is no need to declare an AQMA, but the situation will be closely monitored.

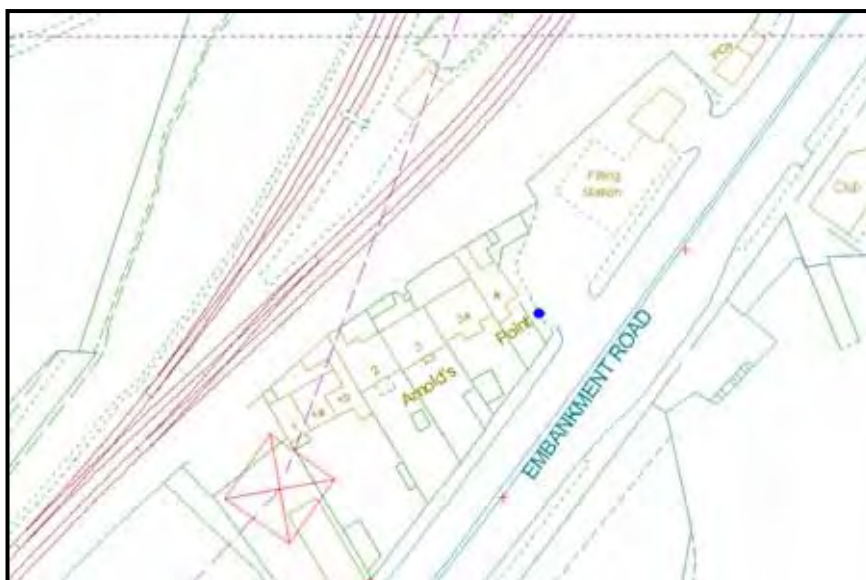
3.7 Embankment Road

Embankment Road consists of the main route in to the city centre from the A38 Expressway. The route is used by all traffic entering the city area, and has a reasonable number of HGV's. The route has varying lanes of traffic, and at its widest has six lanes, but at the point of relevant exposure has four lanes. A small terrace of Victorian properties are situated on the roadside but have reasonable size gardens at the front, meaning that the building façade is approximately 11 metres from the road.

3.7.1 Monitoring Results

A diffusion tube has been installed on a four weekly basis to represent relevant public exposure in the area to the side of one property, at a distance to represent the building façade. Figure 3.11 below shows the exact location of the diffusion tube.

Figure 3.11 Map to show the location of the diffusion tube at Embankment Road to demonstrate relevant exposure.



The monthly mean results from the diffusion tube monitoring are shown in table 3.17 below, as raw data, and is adjusted using the factor of 0.88, as described in section 3.3 above. The mean result is shown for both 2003, and for the mean for all the results.

Table 3.17 Monthly diffusion tube results at Embankment Road.

Embankment Road	Raw data	Adjusted figure
February	43.76	38.51
March	37.28	32.81
April	29.42	25.89
May	36.20	31.86
June	38.02	33.46
July	31.78	27.97
August	40.44	35.59
September	41.60	36.61
October	37.55	33.04
November	40.44	35.59
December	38.79	34.14
Mean for 2003	37.75	33.22
January	23.61	20.78
February	45.15	39.73
Mean	37.23	32.77

When the 2003 mean figure is used to calculate the expected concentrations in 2005 and 2010, using Box 6.6 from LAQM.TG(03), the results are well below both objective figures. The results of this can be seen in Table 3.18.

Table 3.18 Estimate of the annual mean figure for 2005 and 2010, using Box 6.6 from LAQM.TG(03) for monitoring data from roadside sites, in $\mu\text{g}/\text{m}^3$.

	Actual 2003 mean result	Bias adjusted 2003 result	Estimated 2005	Estimated 2010
Embankment Road	37.75	32.22	30.54	25.13

3.7.2 Modelling Results

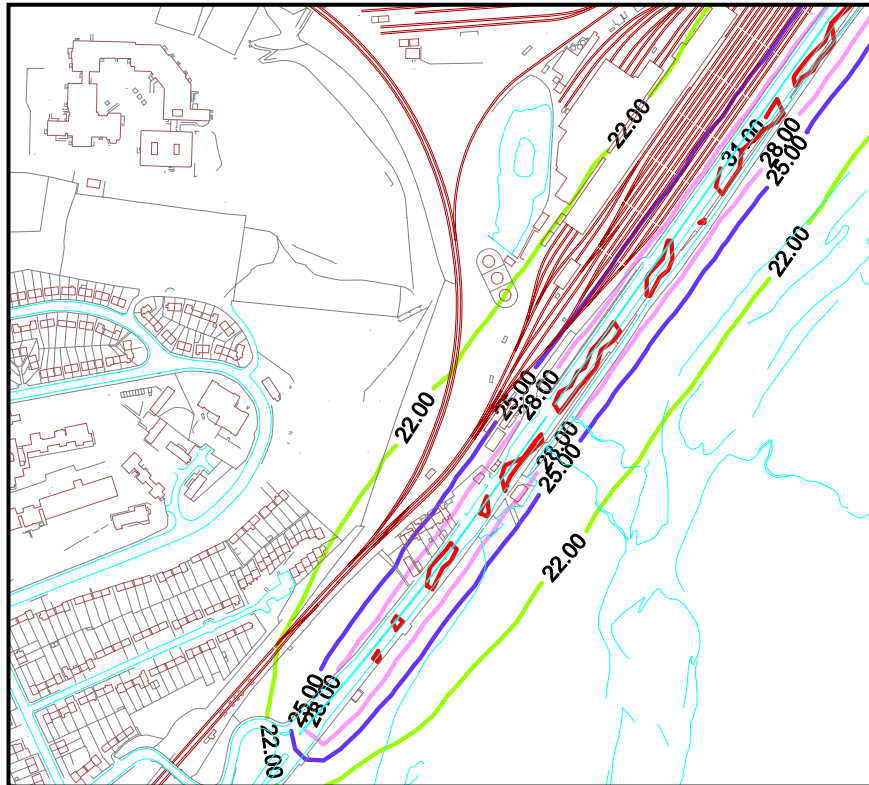
Modelling has been carried out at this location. Details of the AAQUIRE modelling package are explained in 3.4.2, along with an explanation of the input data. Model validation is provided in section 3.8.

Table 3.19 Data input to AAQUIRE for modelling of Embankment Road, 2005.

DATA INPUT	Embankment Road
Surface roughness	Large Town/city
Class	1
Area modelled: SW grid point	250000 55000
Area modelled; NE grid point	250500 55500
Grid space	15
Receptor height	1.5
Year	2005
Road coordinates	250172 55079 250678 55766
Vehicles per hour	4624
% HDV	3.9
Average speed km/hr	60
Road height	0
Road width	14.88
Road type	1 (flat)
Left mix width	0
Right mix width	0
% LDV petrol cold	4
%LDV petrol hot	6
% LDV petrol cold catalyst	25
% LDV petrol hot catalyst	40
% LDV diesel cold	5
% LDV diesel hot	20
% HGV cold	30
% HGV hot	70
Background conc.NOx (ug/m3)	28.65
Default Nox/NO ₂ ratios applied.	Yes
Met data	Plymouth

The modelling predictions using AAQUIRE, predict that the concentrations of NO₂ in 2005 will be significantly below the 40 $\mu\text{g}/\text{m}^3$ objective, with the highest recorded concentration for 2005 being 32.61 $\mu\text{g}/\text{m}^3$. However, it appears from the validation exercise undertaken, that the model is predicting a similar concentration to that obtained from 2003 bias adjusted mean concentration from the diffusion tube monitoring and can therefore be seen to be representative.

Figure 3.12 Contour map to show the concentrations of NO₂ at Embankment Road.



3.7.3 Conclusion of Detailed Assessment for Embankment Road

Both the monitoring results and the modelling results indicate that the 2005 and 2010 objectives for NO₂ will be met. The highest result obtained from the modelling was 32.61 µg/m³ for Embankment Road, compared to 30.72 µg/m³ calculated during the first round of the review and assessment process.

With regard to the monitoring results, the annual mean figure of 32.76 µg/m³ after it had been calculated using the bias adjustment factor seems to relate closely to the model, and follows the Government's presumption that concentrations of NO₂ are expected to fall by 2005.

As a result, there is no need to declare an AQMA, but the situation will be closely monitored.

3.8 Model Validation

For model validation, all of the sites were examined to ensure that the results from the diffusion tubes followed a consistent trend. Each site was then modelled using AAQUIRE, for data from 2003, and the modelling results were compared to both the actual mean value from the tubes and for the bias adjusted means for each of the diffusion tubes. All of the input data for the modelling is described in the relevant sections above for each site. These results can be seen in Table 3.20 below.

Table 3.20 Comparison between monitoring and modelling results of each site for validation purposes.

	Mutley Plain (Shop)	Exeter Street	Embankment Road	Plymouth Road
Diffusion Tube Actual Mean For 2003	59.90	52.03	37.75	35.64
Diffusion tube bias-adjusted mean for 2003 (0.88)	52.71	45.42	32.22	31.36
Forecast for 2005 using Box 6.6	49.97	43.04	30.54	29.73
Model result	32.76	33.43	32.61	30.74

Although the results are fairly consistent for Embankment Road and Plymouth Road, the results for Mutley Plain and for Exeter Street, the busiest and most congested routes within Plymouth are significantly different. These results show that AAQUIRE is underestimating the concentrations of NO₂ significantly.

3.9 Overall conclusions for NO₂

As there is a likelihood that the objectives for NO₂ will be exceeded in 2005 at two locations in Plymouth, it has been decided that air quality management areas will be declared in both Exeter Street and Mutley Plain, despite the modelling results indicating that the objective will be met by the end of 2005.

Further monitoring will be undertaken to examine the extent of the AQMA at both locations.

4.0 Detailed Assessment of PM₁₀

Pollutant	Objective	Measured as	To be achieved by
Particles (PM ₁₀)	50 µg/m ³ Not to be exceeded more than 35 times per year	24 Hour Mean	31 December 2004
	40 µg/m ³	Annual Mean	31 December 2004

4.1 Results and Conclusions from the Updating and Screening Assessment

Conclusion

Information has been gathered on all the sections of the updating and screening assessment checklist. The only concern for PM₁₀ is that associated with the loading of dusty cargoes at two locations, Victoria Wharves and Cattedown Wharves. Further detailed assessment is required at these locations to assess the concentration of PM₁₀ and forecast it to 2004 to see if it will meet the objective.

4.2 The Detailed Assessment

The aim of the detailed assessment is to determine with reasonable certainty whether or not there is a likelihood of the objectives for PM₁₀ being exceeded in 2004.

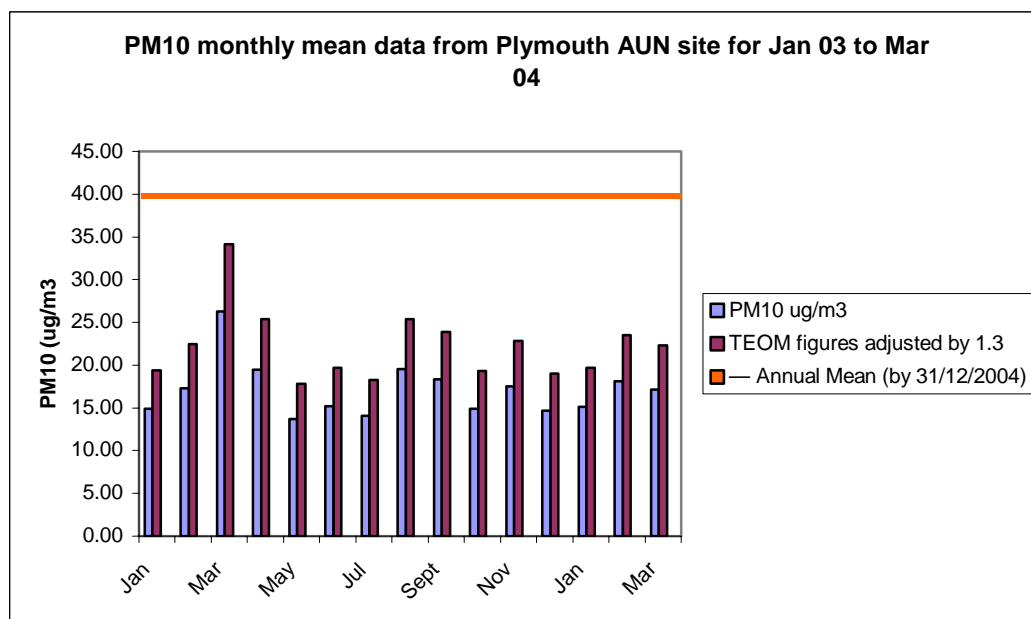
Due to a number of complaints being received about the loading and unloading of dusty cargoes at two port areas within Plymouth, a detailed assessment was required at both locations to assess the likelihood of the air quality objective for PM₁₀ being exceeded at the end of 2004.

4.2 Monitoring of PM₁₀ at the AUN site in Plymouth

Monitoring of PM₁₀ is carried out as part of the monitoring network as an urban background site, using a TEOM. To allow a direct comparison between TEOM data and gravimetric data such as the Partisol, the TEOM data has to be adjusted by 1.3. The results for 2003 are shown in figure 4.1 to indicate the levels that are found around Plymouth.

It is apparent that the concentrations within Plymouth are well within the air quality objective level.

Figure 4.1 Monthly mean values for the AUN at Plymouth.



4.4 Cattedown Wharves

Cattedown Wharves is located on the River Plym and has only one property in close vicinity, which is a public house. The manager of the pub lives at the address and the building façade is located within 16 metres of a warehouse where the loading and unloading of cargo occurs. At the time of the updating and screening assessment, the warehouse was used to store animal feed, which was stored within the warehouse in dry powdered form. When the cargo was loaded in to ships, a truck was used to scoop the product up and deposit it into a large lorry. This activity caused dust to be generated and with a frequent onshore breeze, this often deposited on the windows of the public house.

However, after discussions with the manager of Cattedown Wharves, it was agreed to change the product stored within the warehouse directly adjacent to the public house, to alleviate any dust nuisance. The product has now been changed to ball clay, which due to its nature does not cause dust problems. The warehouse has been let on a 25 year lease for this product only, and as a result it has been decided that there is no need to complete a detailed assessment at this time.

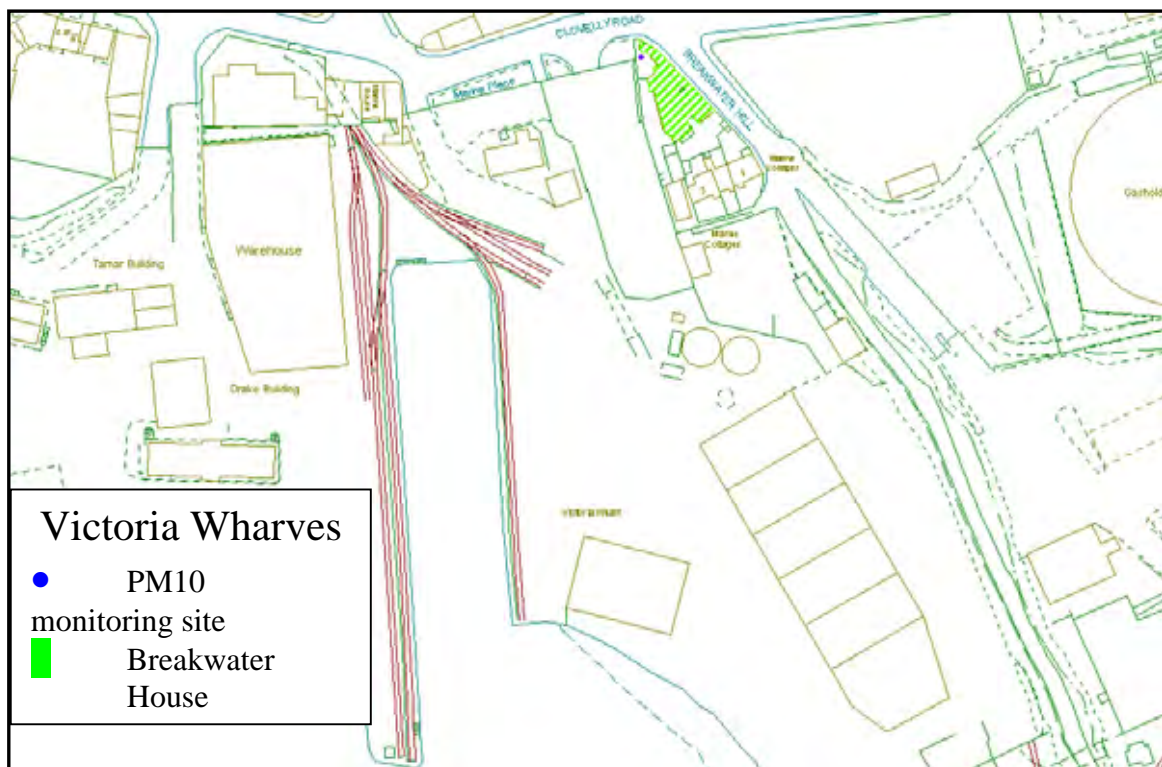
The situation will be kept under review for any future progress reports that are prepared.

4.5 Victoria Wharves

Victoria Wharves is a commercial port which primarily deals with the loading and unloading of China Clay product. The Wharves have been in operation for a significant period of time and is located in a relatively commercial area. However, there are a number of properties located within close proximity, the closest being 77 metres from the dockside which are the source of a number of dust complaints about the activities at the port.

Figure 4.2 shows the location of the dock area, with the closest residential properties highlighted. The apartment block highlighted by the green hashed area was previously a public house but several years ago the property became derelict. However, the owner of Victoria Wharves purchased the property and converted it in to apartments, which have all been sold for residential use.

Figure 4.2 Map to show the monitoring location for Victoria Wharves



In July of 2003, Plymouth City Council witnessed a continuing nuisance at the Wharves and consequently served an abatement notice on the company in an attempt to alleviate the nuisance. However, complaints continue to be received despite the notice remaining in force.

4.5.1 Monitoring of Victoria Wharves

Following the updating and screening assessment, SCA funding was awarded to purchase a gravimetric sequential Partisol monitor, meaning that two weeks of monitoring could be completed between visits to the site. It was decided to put the monitor in the garden of one of the apartments at Breakwater House, where the majority of complaints had arisen from.

The Partisol has a filter that is exposed to the air for a period of 24 hours and at midnight the filter changes to allow the next 24-hour monitoring to commence. This allows a direct comparison to be made with the 24 hour average objective of $50\mu\text{g}/\text{m}^3$. In addition, an annual mean figure can be calculated.

Filters are supplied preconditioned by Advance Environmental, at Exeter University, and are returned to them for analysis. Filters, each with a unique identification number, were conditioned at approximately 20°C ($\pm 1^\circ\text{C}$) and 50% relative humidity for 48 hours before weighing. This procedure was followed both prior to and after deployment to site and was undertaken in order to both minimise the effect of retained moisture on the filter and allow equilibration with laboratory conditions. This permitted the mass concentration to be calculated for each sample. All data was blank corrected.

External calibration of the Sartorius R180D analytical balance is undertaken annually (current certificate number 104859483), whilst internal calibration was undertaken prior to weighing.

The results are specified as a 24-hour result in $\mu\text{g}/\text{m}^3$ and are shown in Table 4.1 below.

Annual Mean Objective

Monitoring has not been completed for the recommended 12 months, and began in October 2003. The results of the annual mean figure from monitoring at the AUN and Victoria Wharves are shown in Table 4.1. The AUN mean has been corrected by 1.3 to provide a direct comparison for the gravimetric monitoring.

Table 4.1 Annual mean results for all monitoring of PM_{10} undertaken in Plymouth.

Location	Annual Mean
Plymouth AUN	17.15
Plymouth AUN (x1.3)	22.30
Plymouth Partisol	32.56

The annual mean concentration as shown in Table 4.1 has been calculated from the gravimetric Partisol monitoring data, to assess the likelihood of exceeding the objective of $40\mu\text{g}/\text{m}^3$. However, this has been based on only several months monitoring data. It is possible to estimate an annual mean figure from a short term monitoring exercise and this has been calculated as shown in Table 4.2, by using Box 8.5 from LAQM.TG(03). This predicted the annual mean concentration to be $36.99\mu\text{g}/\text{m}^3$ using actual monitoring results from both Plymouth and Bristol AUN sites.

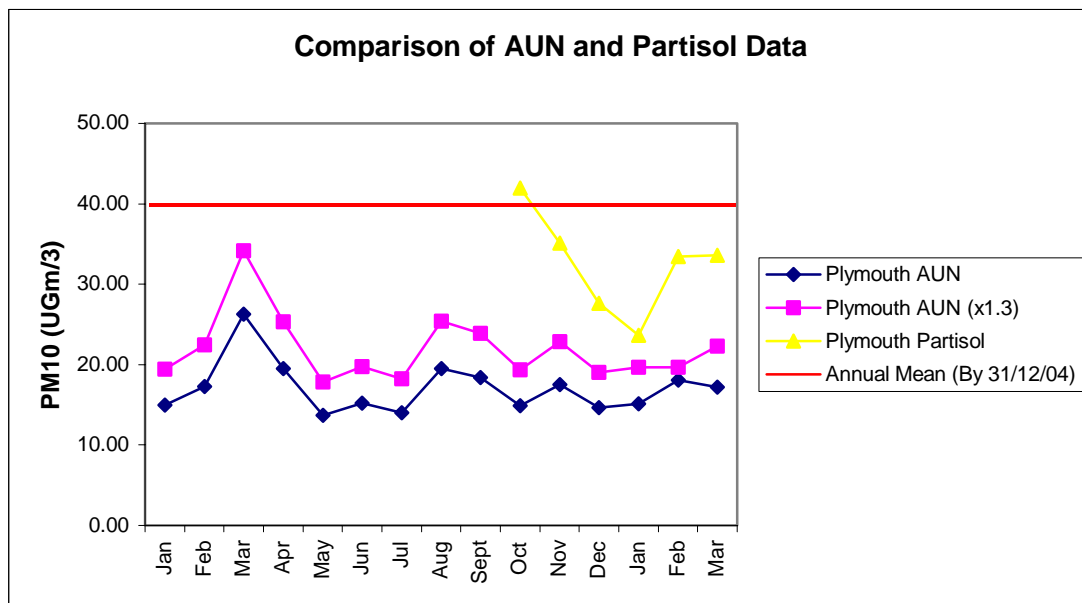
Both the mean figure obtained from monitoring and the calculated annual mean figure are above the concentrations from the AUN, which would be expected as the AUN is a background monitoring site.

Table 4.2 to show the calculation to estimate the annual mean for 2003 for PM₁₀ using gravimetric monitoring data.

1.) Identify 2-4 long term monitoring sites, forming part of the national network	Plymouth AUN Bristol AUN
2.) Obtain annual means for both sites for the year 2003 in $\mu\text{g}/\text{m}^3$	Plymouth 17 Bristol 22
3.) Calculate the period mean for the period of interest (Oct 03 - Dec 03)	Plymouth 15.66 Bristol 21.33
4.) Calculate the ratio of the annual mean to the period mean for each site (Am/Pm).	Plymouth 1.09 Bristol 1.03
5.) Calculate the average of the two ratios to give the adjustment factor.	Average Ratio 1.06
6.) Calculate the period mean for period of interest (Partisol Oct-Dec 03)	Partisol average 34.90
7.) Multiply the measured period mean of the Partisol by the adjustment factor to give the estimated annual mean for 2003	36.99
Estimated annual mean for 2003	36.99 $\mu\text{g}/\text{m}^3$

The results from the AUN and Victoria Wharves are further demonstrated in Figure 4.3 to show the comparison of the AUN data and the gravimetric data.

Figure 4.3 Comparison of AUN data and Partisol data



To forecast the annual mean concentration for 2004 from actual monitoring results in 2003, Box 8.6 from LAQM.TG.(03) was used. This allows a direct comparison to be made with the 2004 objective. The result of this calculation is $30.78\mu\text{g}/\text{m}^3$ using the mean figure provided by monitoring data only and this estimates the annual mean for 2004 to be well below the $40\mu\text{g}/\text{m}^3$ objective. Even if the calculation in Box 8.6 was used to predict the annual mean from the calculated 2003 mean, the result of the 2004 prediction is $36.21\mu\text{g}/\text{m}^3$, which is still below the 2004 objective of $40\mu\text{g}/\text{m}^3$.

Table 4.3 Calculation to estimate the annual mean for PM₁₀ in 2004 using Box 8.6

Step 1 Adjust the TEOM data to gravimetric by X by 1.3	The data is from a gravimetric analyser = 32.56 µg/m ³
Step 2 Derive the local secondary PM ₁₀ concentration from the internet maps for 2001	6.26µg/m³
Step 3 Estimate the local primary PM ₁₀ concentration in 2003 Csec ₂₀₀₀ using the correction factors in Box 8.7.	Cprim ₂₀₀₃ = Csec ₂₀₀₁ X 0.955 = 6.26 X 0.955 =5.9783
Step 4 Estimate the local PM ₁₀ concentration in 2003 Cprim ₂₀₀₃ by subtracting the 2003 secondary concentration and the PM ₁₀ coarse concentration, (assumed to be 10.5,) from the measured PM ₁₀ concentration	Cprim ₂₀₀₃ = CG ₂₀₀₃ – Csec ₂₀₀₃ – 10.5 32.56 – 5.834 – 10.5 = 16.226
Step 5 Adjust the local primary PM ₁₀ in 2003 to 2004 using the correction factors from Box 8.7	Cprim ₂₀₀₄ = Cprim ₂₀₀₃ X 0.930 / 0.954 = 16.226 (0.930/ 0,954) = 14.71
Step 6 Calculate the secondary PM ₁₀ in 2004 using the correction factors in Box 8.7	Csec ₂₀₀₄ = Csec ₂₀₀₁ x 0.932 = 5.57
Step 7 Calculate the total estimate PM ₁₀ concentraion in 2004 by adding the components together	CG ₂₀₀₄ = Cprim ₂₀₀₄ + Csec ₂₀₀₄ + 10.5 = 14.71 + 5.57 + 10.5 =30.78µg/m³

Exceedence of the 24- hour objective

Since the monitoring began, there have been 10 exceedences of the 24-hour objective, but this is below the 35 times exceedence limit specified in the air quality guidance. However, it is accepted that more exceedences of the 24-hour objective would be expected in the summer months and monitoring has only been completed for the winter months.

When an estimate is made of the number of 24-hour exceedences expected from the concentrations discussed above, guidance suggests that the estimated concentration can be plotted on Figure 8.1 in LAQM.TG(03). When this is carried out for both the results from above, the number of exceedences are shown in Table 4.4 below.

Table 4.4 Estimation of the number of 24-hour exceedences using predicted annual mean figures for 2004.

Estimated result for 2004 for PM ₁₀	Number of exceedences
Using mean data from monitoring	32
Using estimated mean data from box 8.6	55

These results suggest that there will be a large number of exceedences of the objective of 50µg/m³ in 2004, especially when estimating the annual mean concentration.

Modelling has not been carried out of the predictions of the concentrations of PM₁₀ for future years. However, as suggested in guidance, the filters are currently being chemically analysed and speciated. The results of this will be presented in the next air quality report.

4.6 Conclusion

Monitoring was only required at one of the suggested two locations from the updating and screening assessment, due to different loading product being used, causing minimal dust problems.

However, at Victoria Wharves, the loading of china clay had continued to cause dust complaints. Gravimetric monitoring equipment was installed, in the form of a Partisol, within the garden of a residential property and whilst monitoring has only been underway for six months, there have only been 10 exceedences of the $50\mu\text{g}/\text{m}^3$ objective, far fewer than the 35 permitted exceedences, though it is accepted that monitoring has only been undertaken through the winter months and higher concentrations are expected in the summer.

The mean figure for only a couple of months of monitoring for 2003 has suggested that the annual objective is being met. When this is calculated to provide an annual mean figure, the predictions using Box 8.5 from guidance suggest that the estimated annual mean is below the objective for the end of 2004. In addition, when the 2003 annual mean is used to predict the concentrations in 2004, the concentrations again fall below the objective of $40\mu\text{g}/\text{m}^3$. However, when this was forecast using Figure 8.1 in guidance, for the 2004 exceedences, the number of exceedences predicted rose sharply to suggest a possible problem in 2004.

Although the predictions for 2004 provide some differing information, in that the annual mean objective may be met but the 24-hour objective may be exceeded, it is not intended to declare an air quality management area as the local authority cannot be satisfied that the objectives for 2004 will be exceeded. Monitoring will continue at the location for the next 12 months including monitoring over the summer months to ensure a more accurate assessment of the objectives is undertaken and the situation will be kept under review.

5.0 The Next Step

The detailed assessment has revealed that several air quality management areas are required. Firstly, two AQMA's are recommended for Mutley Plain and Exeter Street in Plymouth, as a result of traffic emissions. Both of these are main arterial routes in to the city centre. Both sites will need further detailed monitoring to clarify the concentrations of NO₂ over the forthcoming year. However, it is possible to determine with reasonable certainty that an AQMA will be required at both locations.

Exeter Street Petrol Station has caused some concerns due to the close proximity of Holy Cross School, which is a primary school. Monitoring has been carried out using only diffusion tubes and as these are not entirely accurate, more accurate and detailed monitoring needs to be carried out. As this is likely to be expensive, an application for funding from DEFRA will be necessary. The type of monitoring is yet to be determined and some assistance has been sought from the Monitoring Help Desk with regard to suitable equipment.

As for PM₁₀ monitoring at Victoria Wharves, there is not enough information at the present time to suggest that the objectives will not be met. There is no evidence to suggest that the annual mean will be exceeded but there is some indication that the number of exceedences of the 24-hour objective will be breached. However, monitoring will continue over the next twelve months to assess the number of exceedences of the 24-hour objective, and the situation will be reviewed in 12 months.

6.0 Bibliography

LAQM.TG(03) (2003) Technical Guidance DEFRA

Updating and Screening Assessment of Air Quality in Plymouth
May 2003

AAQUIRE Instruction Manual 2003

7.0 Appendices

Appendix 1: Quality Assurance and Control Measures

Nitrogen Dioxide Diffusion Tubes

Where NO₂ is monitored using diffusion tubes, the standard method recommended by NETCEN and the analytical laboratory undertaking analysis (Gradko) is followed. Gradko are a fully accredited establishment and supply tubes to many local authorities.

NO₂ diffusion tubes are clear plastic tubes, with one open end and a closed end containing a NO₂ absorbing chemical matrix (triethanoamine). The type of tubes used are 20% TEA in water. The open end is sealed with a plastic cap before it is transported to the monitoring location. At the site the cap is removed and the tube is mounted vertically with the open end at the bottom.

The interval between preparation and deployment is kept to a minimum. During storage the tubes are kept in a sealed plastic bag in the refrigerator. A blank tube is sent which remains in the sealed bag during the monitoring period and is returned with the rest of the tubes to the laboratory for analysis.

Monitoring sites were identified upon relevant exposure or those that were considered to be representative of a relevant exposure location. The tubes were mounted mostly on drainpipes. Ideally, the tubes should be mounted on to spacer blocks and not attached directly to any surface. Tubes, however, are prone to theft and are, therefore, attached using strong tape above head height. The tubes are exposed for a period of four weeks and the exposure time noted in hours.

Quality assurance is given by participation in the Working Sampling Proficiency Programme (WASP). These tests provide a regular independent check on the calibration. Based upon these findings analysis conducted by Gradko for April 2003 is determined to have an accuracy of -5.17%. Gradko also participate in the Field Intercomparison Tube Survey where diffusion tubes are co-located against an AUN site. This gives a bias factor of +14%. When this is compared to the bias adjustment factor calculated using the co-location study at Plymouth AUN site a good correlation is found.

The analytical lab used was Gradko International Ltd., St Martins House, 77 Wales Street, Winchester, Hampshire SO23 0RH.

Benzene Diffusion Tubes

Benzene diffusion tubes are supplied by Gradko. Analysis is carried out using gas chromatography/ Thermal desorption techniques. Standard solutions are prepared covering the concentration range 10-2000ng and there is an uptake rate of 1.28ng per ppm per minute. The exposed tubes are thermally desorbed and the vapour phase transferred to a gas chromatography system. Calibration determinations are made for every batch of tubes analysed.

Results are issued in parts per billion and are then converted to µg/m³. The interval between preparation and deployment is kept to a minimum and after tubes are dispatched they are stored within the refrigerator until deployment to site. A blank tube has now commenced with a tube being left within the refrigerator for the exposure period and returned with the tubes after exposure.

Monitoring locations have been chosen to represent relevant exposure locations to represent the annual mean concentration, although the accuracy of the tubes may be +/-25%. When the tubes are placed out at the monitoring locations, the red cap is removed and a filter is placed on the end of the tube. The tubes are left for 4 weeks and when collected, the filter is removed and the cap is placed on the tube. The tubes are then sent away to the laboratory for analysis.

Quality assurance is given by the participation in the WASP scheme. The analytical laboratory take part in the Workplace Analysis Scheme for Proficiency (WASP) run by the UK Health

and Safety Laboratories. Samples of BTEX loaded tubes are sent to each laboratory three times per year for analysis.

The laboratory methods and procedures used for this analysis form part of the Quality Management Systems which has been written to comply with the requirement of UKAS.

Pumped Benzene Diffusion Tube.

The National Physics Laboratory co-ordinate a national survey, that Plymouth participate in. The pumped sampler is located at the AUN site, in Armada Way, and is considered an urban background site. Benzene tubes are provided fortnightly and the local site operator changes the tubes, checks and adjusts the flow rate accordingly. All procedures in the manual provided by NPL are followed.

NPL audit the sampler every six months to check that the box is not leaking, measure the flow through the two tubes and correct it if it is more than 10% out. If the flow is greater than 10% out then the data is scaled accordingly.

The absorbent is carbopack x. The uptake rate does not apply due to it being a pumped sampler.

AUN Network

Monitoring data obtained from Plymouth City Council's automatic monitoring site in Armada Way is affiliated to the DEFRA's AUN network. As such it follows all QA/QC procedures set out in the local site operators manual. Daily internal calibrations are conducted as well as fortnightly calibrations to check equipment performance and internal instrument parameters. Provisionally scaled data is available on the internet. Performance audits and inter calibrations are additionally conducted by agencies appointed by the DEFRA. The data is ratified every 6 months by NETCEN, and is reported every 6 months in the QA/QC Data Ratification Report for the Automatic Urban Network. This is, a report produced for the Department for Environment, Food and Rural Affairs, Scottish Executive, Welsh Assembly Government and the DoE in Northern Ireland.

NO₂ chemiluminescent monitor

Monitoring at the location of Mutley Plain is not linked to any particular network. However, procedures have been written to ensure a calibration is carried out two weekly at the site. The data is due to be loaded in to a software programme at the main office via a modem but due to difficulties this has yet to be done. The data has been collected to date from Eti head office and sent via e-mail to the Civic Centre. The data is examined for any spurious results or anomalies, and these are removed. The results have been averaged over 24 hours and calculated as monthly mean figures.

Routine site visits are carried out to maximise data capture and integrity of data. These operations include:-

- Ensuring the proper running of the equipment
- Performing instrument calibrations and diagnostic checks
- Minimising instrument down time by anticipating problems prior to them occurring
- Carrying out essential routine functions such as filter changes
- Performing checks of the automatic calibration system.

To enable the data to be scaled, it is necessary to calibrate the equipment using a gas mixture of known concentration. Calibrations are conducted as a daily automatic calibration and as a two weekly manual calibration. These are carried out in accordance with the manual provided by the manufacturer.

An ongoing maintenance contract is in place with Casella Eti, the supplier of the equipment, and it is intended to visit the site six monthly to service the equipment. However, as the

equipment is new and still undergoing work to download the data, visits are occurring more regularly at the current time.

The service contract also covers attendance at site in the event of a breakdown.

Data capture has not been assessed at the moment due to missing data for the first few weeks of monitoring, and the inability at the current time to connect with the monitor on a daily basis. This is currently a subject of discussion between the supplier and the council, but will be resolved at the earliest opportunity.

Gravimetric Partisol Monitor

The Partisol has a filter that is exposed to the air for a period of 24 hours and at midnight the filter changes to allow the next 24-hour monitoring to commence. This allows a direct comparison to be made with the 24 hour average objective of $50\mu\text{g}/\text{m}^3$. In addition, an annual mean figure can be calculated from the results.

Filters are supplied preconditioned by Advance Environmental, at Exeter University, and are returned to them for analysis. Filters, each with a unique identification number, were conditioned at approximately 20°C ($\pm 1^\circ\text{C}$) and 50% relative humidity for 48 hours before weighing. This procedure was followed both prior to and after deployment to site and was undertaken in order to both minimise the effect of retained moisture on the filter and allow equilibration with laboratory conditions. This permitted the mass concentration to be calculated for each sample. All data was blank corrected.

External calibration of the Sartorius R180D analytical balance is undertaken annually (current certificate number 104859483), whilst internal calibration was undertaken prior to weighing.

Appendix 2

Results of the pumped benzene sampler at the AUN compared to the co-location of a benzene diffusion tube.

Correspondence from Brian Jones at NETCEN.

Appendix 3

Monthly and annual mean results for all diffusion tube monitoring.

