Copeland Air Quality Review and Assessment Progress Report 2007

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Executive Summary

As part of the National Air Quality Strategy (NAQS), local authorities are required to undertake a Progress Report of air quality in their areas in years when they are not carrying out their three yearly Updating and Screening Assessment or carrying out a Detailed Assessment.

The 2006 Updating and Screening Assessment and the 2007 Progress Report both concluded that it was unlikely that the air quality objectives for any of the seven pollutants would be exceeded within Copeland Borough.

The results of the current pollutant monitoring programme within Copeland are presented in this report and are compared with previous years. The current pollutant monitoring programme, using diffusion tubes, began in the spring of 2000 at numerous locations throughout Copeland. The pollutants monitored were nitrogen dioxide (NO_2), sulphur dioxide (SO_2), benzene (C_6H_6) and ozone (O_3).

If the current monitoring campaign highlights areas of elevated concentrations of any of these pollutants, it may be advisable to consider more detailed monitoring in these areas. Ozone was also monitored due to a lack of emission source data and monitoring data in Copeland. Ozone is assessed at a national level, rather than by local authorities, with the UK having to meet the requirements of the 2nd Daughter Directive by 31st December 2005.

The results of the air quality monitoring programme in the Borough of Copeland show that, in general, the concentrations of three of the four pollutants monitored are below the NAQS objectives (NO_2, SO_2 and benzene). It is therefore considered that these three pollutants are present in concentrations at which adverse health effects are either not observed or, in the case of benzene, represent a very small risk to health.

The exception to this is O_3, where high monthly concentrations (>100 $\mu g\ m^{-3}$) have been recorded at many of the ten O_3 monitoring sites around the Borough during the five year period. The monitoring results are monthly average concentrations, whilst the 2nd Daughter Directive objective for O_3 is an 8-hour running mean value. Therefore, no direct comparison of data can be undertaken.

There has been one new development which may impact on air quality, by causing an increase in traffic flow. The construction of the Distington bypass, to the west of the A595, commenced during 2006 causing a potential increase in heavy goods vehicles on the A595 delivering aggregate to the site from Eskett Quarry. A new monitoring point was introduced at the Castle Inn in Distington in December 2006, which recorded NO_2 air concentrations of 35 $\mu g\ m^{-3}$. When complete, the bypass will divert traffic from the A595 between Distington and Howgate, thus reducing congestion in the village of Distington and improving air quality. This will be investigated further during the next Updating and Screening Assessment.

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1. Introduction

1.1 History of the Air Quality Strategy

The Environment Act 1995 requires the UK Government and the devolved administrations for Scotland and Wales to produce a National Air Quality Strategy (NAQS) containing standards, objectives and measures for improving ambient air quality and to keep these policies under review. In 1997 the first Air Quality Strategy was adopted[1]. This was replaced by the Air Quality Strategy for England, Scotland, Wales and Northern Ireland published in January 2000[2]. It established the framework for achieving further improvements in ambient air quality in the UK to 2003 and beyond. The strategy identified actions at local, national and international level to improve air quality. It was followed by an Addendum[3] in February 2003 which tightened several of the objectives and introduced a new objective. A review of the 2000 Air Quality Strategy led to the introduction of the 2007 Air Quality Strategy in July 2007[4]. This latest strategy retains the objectives set out in the previous strategy and its addendum, however, it replaces the provisional 2010 PM_{10} objective in England, Wales and Northern Ireland with the exposure reduction approach (DEFRA, 2007). The strategy also introduces a new ozone objective to protect ecosystems, in line with the EU target value set out in the Third Daughter Directive.

As part of the NAQS, local authorities are required to undertake a progress report of air quality in their areas in years when they are not carrying out their three-yearly Updating and Screening Assessment or carrying out a Detailed Assessment. This report is a requirement of local authorities and takes account of the guidance from DEFRA (DEFRA 2003a and DEFRA 2007).

1.2 Air Quality in Copeland Borough Council

Copeland Borough Council has, since April 2000, monitored reactive oxides of nitrogen, sulphur dioxide, benzene and ozone at 16 sites throughout the Borough using diffusion tubes changed on a monthly basis. Copeland Borough Council produced an Updating and Screening Assessment of local air quality in August 2006 which concluded that air quality was unlikely to exceed the objectives for the seven pollutants identified in the NAQS (Lutman, 2006). Furthermore, it was not considered necessary to undertake a Detailed Assessment for any pollutant. No Air Quality Management Areas are declared within Copeland Borough.

The production of a Progress Report is designed to enable local authorities to maintain continuity in the LAQM process between Detailed Assessments and Updating and Screening Assessments. Authorities are able to report progress on implementing local air quality management and achieving or maintaining concentrations below the air quality objectives. The report also gives local authorities the opportunity to communicate air quality information to residents of the area and other interested parties as well as maintaining an up to date record of air quality data. This should enable the authority to act in a timely manner should further measures be required to improve air quality. This report presents results of a Progress Report for 2007.

[1] The United Kingdom National Air Quality Strategy, March 1997 (Cm 3587)
[2] The Air Quality Strategy for England, Scotland, Wales and Northern Ireland – Working Together for Clean Air, January 2000 (Cm 4548, SE2000/3, NIA 7).
[3] The Air Quality Strategy for England, Scotland, Wales and Northern Ireland: Addendum, February 2003.
[4] The Air Quality Strategy for England, Scotland, Wales and Northern Ireland DEFRA 2007,

2. Monitoring Results

2.1 Nitrogen Dioxide

The NAQS objectives for nitrogen dioxide (NO_2) are 40 $\mu g\ m^{-3}$ as an annual mean and 200 $\mu g\ m^{-3}$ as a 1-hour mean (not to be exceeded more than 18 times a year), both to be achieved by the end of 2005. There is an additional objective of 30 $\mu g\ m^{-3}$ as an annual mean for the protection of vegetation and ecosystems. The annual mean objectives are the most stringent of the objectives.

Monitoring of NO_2 concentrations in Copeland has been ongoing since 1993. In the current monitoring campaign which started in April 2000, 24 monitoring sites are located throughout the Borough from Millom in the south, to Distington in the north and to Wasdale in the east. The monitoring sites represent a wide range of environments from rural (background concentration) sites to urban sites and kerbside/roadside sites. At the end of 2006 a new diffusion tube was introduced at a kerbside location on the A595 at the Castle Inn, Distington. This was introduced to monitor the effect of congestion caused by construction of the Distington Bypass. The distribution of the NO_2 monitoring sites can be seen in Figure A1 (see Appendix A).

2.1.1 Results

The diffusion tube monitoring results for NO_2 for each location for 2006 and 2007 together with the percentage change and a projection forward to 2010 are shown in Table 1. The trends in annual average concentrations from 1993 to 2007 are presented in Figure 1, which also shows the annual NAQS objective for comparison.

2.1.2 Discussion of results

The results show that average NO_2 concentration at all monitoring sites in Copeland are below the NAQS annual average objective of 40 $\mu g\ m^{-3}$. Four of the 24 sites had an annual concentration greater than 20 $\mu g\ m^{-3}$, namely Lowther Street, Scotch Street and the Civic Hall (all in Whitehaven) and the A595 in Distington. Kerbside sites show average increases of 6%, from 2006 to 2007 and intermediate and background sites both show decreases of 10%, over the same period. Concentrations for 2010 were estimated using projection factors of 0.92 and 0.89 for background / intermediate and roadside sites respectively, and are all below 40 $\mu g\ m^{-3}$. However, a projected concentration of 32 $\mu g\ m^{-3}$, is predicted for the A595 at Distington in 2010, 2 $\mu g\ m^{-3}$ higher than the annual objective for ecosystems (30 $\mu g\ m^{-3}$). The concentrations of NO_2 in Distington are expected to reduce once the bypass opens, predicted for late 2008. All other sites are projected to be below 20 $\mu g\ m^{-3}$ in 2010 except for Scotch Street which has a projected concentration of 28 $\mu g\ m^{-3}$.

2.2 Sulphur Dioxide

2.2.1 Introduction

The NAQS objectives for sulphur dioxide (SO_2) are 350 $\mu g\ m^{-3}$ as a 1-hour mean (not to be exceeded more than 24 times per year) to be achieved by the end of 2004, 125 $\mu g\ m^{-3}$ as a 24-hour mean (not to be exceeded more than 3 times per year) to be achieved by the end of 2004 and 266 $\mu g\ m^{-3}$ as a 15-minute mean (not to be exceeded more than 35 times per year) to be achieved by the end of 2005. There is an additional objective of 20 $\mu g\ m^{-3}$ as an annual mean

and a winter average for the protection of vegetation and ecosystems. The most stringent of these is the 15-minute mean objective.

The most recent diffusion tube monitoring campaign for SO_2 in Copeland began in April 2000 at eight sites. The sites were chosen either due to their proximity to industrial sites producing SO_2 (e.g. Rhodia Ltd on the outskirts of Whitehaven and Fellside Heat and Power on the Sellafield site) or within residential areas not classified as smoke control zones and which have not had previous SO_2 monitoring (Cleator Moor and Egremont). The distribution of the SO_2 monitoring sites are shown in Figure A2 (see Appendix A).

2.2.2 Results

Ambient concentrations of SO_2 recorded in 2006 and 2007 can be seen in Table 2. The 99.9th percentile (equivalent to 35 exceedences per year) of 15-minute mean concentrations are calculated from the annual average monitored concentrations using the method of Pratt and Dalton (2000) explained in detail below. The trends in annual average concentrations from 2000 to 2007 are presented in Figure 2 which also shows the annual and 15 minute NAQS objectives for comparison.

2.2.3 Discussion of results

The maximum monthly recorded concentration of 15 $\mu g\ m^{-3}$, (observed during July), and the maximum annual average of 3.0 $\mu g\ m^{-3}$ were both measured at Seacliffe Garage, Kells. This may be compared to the maximum monthly average during 2006 of 22 $\mu g\ m^{-3}$ also observed at Seacliffe Garage, Kells. The monthly average SO_2 concentrations cannot be compared directly to the 15-minute NAQS objective. However, Pratt and Dalton (2000) have devised a method to estimate the 99.9th percentile of 15-minute means (equivalent to 35 exceedences per year) from annual mean concentrations in order to overcome the discrepancy between monitoring data and the NAQS objectives (Equation 1).

99.9th percentile of 15-minute means (in ppb) = annual mean (in ppb) * 13.6818 *Equation 1*

It can be seen from Table 2 that the calculated 99.9th percentiles of 15-minute means are below the 15-minute mean NAQS objective of 266 $\mu g\ m^{-3}$ during both years. The 15-minute average mean in 2007 decreased by an average of 7% from the values in 2006. The 15-minute average concentration during July at Seacliffe Garage, Kells was 206 $\mu g\ m^{-3}$ following the method of Pratt and Dalton (2000), which is below the NAQS objective.

The annual mean concentrations of SO_2 recorded in Copeland during 2007 are also below the 20 $\mu g\ m^{-3}$ limit for the protection of Ecosystems(Table 2).

2.3 Benzene

2.3.1 Introduction

The NAQS objective for benzene (C_6H_6) is 16.25 $\mu g\ m^{-3}$ (5 ppb) as a running annual mean to be achieved by the end of 2003. An addendum to the NAQS in February 2003 (DEFRA 2003b) set a longer term objective to reduce the annual mean to 5 $\mu g\ m^{-3}$ (1.5 ppb) by 2010.

In the UK, the main source of benzene is the combustion, production and distribution of petrol. Benzene is carcinogenic to both humans and animals. Due to the nature of genotoxic carcinogenic substances (exposure to even very small amounts of the substance causes an increase in the risk of cancer), no absolute safe concentration can be specified for ambient concentrations of benzene (DETR, 2000). The objective of 16.25 $\mu g\ m^{-3}$ represents very

small risk to health (DETR, 2000), however, exposure to benzene should be kept as low as practicable.

Monitoring of benzene within Copeland using diffusion tubes has occurred since the spring of 2000 at 15 sites. Site locations were chosen due to their proximity to petrol stations and busy roads. In addition, background sites were also monitored (i.e. sites away from any obvious source of benzene). The distribution of the benzene monitoring sites are shown in Figure A3 (see Appendix A).

2.3.2 Results

The latest monitoring results for benzene for 2006 and 2007 together with the percentage change and a projection forward to 2010 are shown in Table 3. The trends in annual average concentrations from 2000 to 2007 are presented in Figure 3 which also shows the 2003 and 2010 annual NAQS objectives for comparison.

2.3.3 Discussion of results

It can be seen in Table 3 that the concentrations of benzene recorded in Copeland are all significantly below the 2003 NAQS running annual mean objective of 16.25 $\mu g\ m^{-3}$. The air concentrations are also below the 2010 NAQS annual mean objective of 5 $\mu g\ m^{-3}$. Concentrations of benzene in 2007 have decreased by an average of 32% since 2006.

At the start of the benzene monitoring campaign in April 2000, four of the diffusion tubes were located at petrol filling stations, directly above the fuel pumps. This was not considered to be representative of locations where members of the public were likely to be exposed for any significant period of time. In February 2004, these four diffusion tubes were relocated to sites close to the filling stations where members of the public are more likely to be regularly exposed.

2.4 Ozone

2.4.1 Introduction

Ozone (O_3) has a target of 100 $\mu g\ m^{-3}$ (not to be exceeded more than 25 times per year averaged over 3 years) as the daily maximum of running 8-hour means to be achieved by the end of 2005. This objective is not currently included in the regulations for the purposes of local air quality management (LAQM). The European Union has also set an additional target of 18000 $\mu g\ m^{-3}$ measured as AOT40[5] for the protection of vegetation and ecosystems.

Unlike the other pollutants, O_3 is not emitted directly from particular sources, but is produced through chemical reactions initiated by sunlight. Various chemicals in the atmosphere such as oxides of nitrogen (NO_x) and volatile organic compounds (VOCs) can undergo chemical reactions to produce O_3. Therefore, sources of NO_x and VOC's can also provide indirect sources of O_3. Since the formation of O_3 is initiated by sunlight, it follows that concentrations of O_3 are higher on sunny days than at night-time or during overcast periods. High concentrations of O_3 are known to cause a decrease in yields of agricultural crops and cause growth reduction in natural and forest vegetation (CLAG, 1996). In humans, very high concentrations of O_3 cause irreversible damage to the respiratory lining followed by inflammatory reactions. High concentrations of O_3 can cause irritation to the eyes and nose

[5] Calculated from 1h values May-July. Accumulated dose over a threshold of 40 ppb (AOT40) is the sum of the differences between hourly concentrations greater than 80 $\mu g\ m^{-3}$ (=40 ppb) and 80 $\mu g\ m^{-3}$, over a given period using only the 1-hour averages measured between 0800 and 2000.

and low concentrations may cause minor changes in the respiratory linings in humans (DETR, 2000).

Diffusion tube monitoring of O_3 has been carried out in Copeland from April 2000 to December 2006 at 10 sites. In 2007 the 2 diffusion tubes located on Sca Fell were discontinued. The distribution of the O_3 monitoring sites are shown in Figure A4 (see Appendix A). Most of the sites for the O_3 monitoring programme were chosen because they were already being used to monitor concentrations of NO_2, one of the precursors of O_3 formation. The remaining sites were chosen in order to provide background concentrations (i.e. away from any obvious anthropogenic sources of O_3 precursors). However, high concentrations of O_3 often occur in areas where there are no anthropogenic sources of O_3 precursors. Formation of carbon monoxide, methane and certain VOC's by plants, trees and other natural sources can act as precursors to O_3 formation. In addition, O_3 formation may occur over a period of hours and even days, and once formed may persist for several days. For these reasons, the transport of O_3 over long distances is possible and concentrations of O_3 monitored at one location may have resulted from VOC and NO_x emissions hundreds, or even thousands, of kilometres away. Unlike most other pollutants, concentrations of O_3 are often higher in suburban and rural areas than in city/town centres because nitric oxide (NO) from traffic emissions may react with O_3 to produce NO_2, thus reducing O_3 concentrations and increasing NO_2 concentrations.

2.4.2 Results

Ambient concentrations of O_3 in 2006 and 2007, together with the percentage change between the 2 years, can be seen in Table 4. The maximum annual average concentration of 89 $\mu g\ m^{-3}$ at the National Trust Campsite, Wasdale, compared to the maximum concentration of 209 $\mu g\ m^{-3}$ measured in 2006 at Lingmell Nose, Sca Fell. An average decrease of 5% occurred since 2006. The trends in annual average concentrations from 2000 to 2007 are presented in Figure 4 which also shows the 8-hour mean NAQS objective, although these values should not be compared directly.

2.4.3 Discussion of results

The annual average monitored concentrations shown in Table 4 and Figure 4 are not directly comparable to the 8-hour running mean NAQS objective (not to be exceeded more than 10 times per year, equivalent to the 97th percentile value). In order to compare the Copeland monitoring results (annual mean equivalent) to the NAQS objective, it was necessary to find some way of linking the annual average concentrations to a comparable 97th percentile of 8-hour mean concentration. This was done by comparing annual mean concentrations (from the National Air Quality Information Archive[6]) to 97th percentile of 8-hour mean concentrations (DETR, 2000) for sites in the National Automatic Monitoring Network. From this, an approximate range of annual average concentrations that compare to the NAQS objective concentration could be derived. Table 5 shows a range of 97th percentile of 8-hour mean concentrations with their corresponding annual mean concentrations for 15 sites from the National Automatic Monitoring Network. The sites chosen were five sites with the highest concentrations for O_3, five sites whose 97th percentile of 8-hour mean concentrations were the same as the NAQS objective for O_3 (100 $\mu g\ m^{-3}$) and five sites with the lowest concentrations for O_3 (DETR, 2000).

Data in Table 5 can be used as an approximate guide for comparing the Copeland monitoring results to the NAQS objective for O_3. It can be seen in Table 4 that all locations experience

[6] http://www.airquality.co.uk/archive/index.php

annual average concentrations ranging from 61 to 88 µg m^{-3} which would probably result in 97th percentile concentrations of 8-hour means of at least, or even greater than 100 µg m^{-3}. It can be seen in Table 5 that annual average O_3 concentrations of 36 µg m^{-3} give rise to 97th percentile of 8-hour mean concentrations at or in excess of the proposed NAQS objective concentration.

DETR (2000) suggest that minor changes in respiratory airways are possible due to O_3 concentrations of 160 µg m^{-3}, whilst for most healthy individuals health effects from exposure to O_3 will probably occur at concentrations of 200 µg m^{-3} or greater. Most of the monthly average concentrations recorded in Copeland are below both of these concentrations although in 2006 very high concentrations (up to 270 µg m^{-3} in May 2006) were recorded at Lingmell Nose (Scafell Massif) and the summit of Scafell Pike which are no longer monitored. It must be remembered that some ozone is transported to ground level from the stratosphere and can also be transported by wind from other locations. Higher concentrations may also be expected where there are very low concentrations of nitric oxide, usually present at higher concentrations in urban areas as a result of traffic fumes.

Due to the long-lived nature and long-range transport capabilities of O_3 (as described in Section *2.4.1*) such high concentrations in Copeland could be the result of a combination of natural emissions of O_3 precursors, anthropogenic emissions of O_3 precursors and transport of O_3 into the region from afar. It is, therefore, difficult to attempt to control the concentrations of O_3 in the air at a local scale and it is envisaged that a Europe-wide strategy for the reduction of O_3 concentrations will be developed (DETR, 2000).

3. Other NAQS Pollutants

3.1 Polycyclic aromatic hydrocarbons

Polycyclic aromatic hydrocarbons (PAH) have an objective of 0.25 ng m^{-3} of Benzo (a) pyrene (BaP) as an annual average to be achieved by 31 December 2010. No monitoring of BaP is currently undertaken in Copeland. BaP is monitored at Hazelrigg as part of the Toxic Organic Micropollutants (TOMPs) network, with an annual average of 0.11 ng m^{-3} measured during 2006.

3.2 Particles

Particles measuring 10µm or less (PM_{10}) have an annual mean objective of 40 µg m^{-3} to be achieved by the end of 2004 and an objective of 50 µg m^{-3} as a 24 hour mean, not to be exceeded more than 35 times per year.

There is a new objective for particles measuring 2.5µm or less ($PM_{2.5}$) of 25 µg m^{-3} as an annual mean, to be achieved by 2010. There is also a target of 15% reduction in concentrations of $PM_{2.5}$ at urban background locations to be achieved between 2010 and 2020.

No monitoring of particulates is currently undertaken in Copeland, however, continuous monitoring conducted during 2004 using an Ambient Particulate Monitor (APM950) PM_{10} at the Civic Hall, Whitehaven (Lutman 2007a) gave an average of 20µg m^{-3} which is below the new objective.

3.3 Carbon monoxide

Carbon monoxide (CO) has an objective of 10 mg m^{-3} measured as an daily running 8 hour mean. There have been no monitoring exercises within the Borough of Copeland since the first and second stage review and assessments which concluded there was negligible risk of the objective being exceeded. The 2006 Updating and Screening Assessment concluded that it is unlikely that the Air Quality Objective for carbon monoxide would be exceeded within the Borough of Copeland and that the current air quality objectives for Copeland should be met without any further reduction in traffic emissions.

3.4 1,3 Butadiene

1,3 butadiene (C_4H_6) has an objective of 2.25 $\mu g\ m^{-3}$ measured as a running annual mean. There have been no monitoring exercises within the Borough of Copeland since the first and second stage review and assessments which concluded there was negligible risk of the objective being exceeded. The 2006 Updating and Screening Assessment concluded that it is unlikely that the Air Quality Objective for CO would be exceeded within the Borough of Copeland and that the current air quality objectives for Copeland should be met without any further reduction in traffic emissions.

4. New Local Developments

The Progress Report Guidance (LAQM.PRG 03) requires that any new local developments that have taken place and which may affect air quality are logged so that they can be considered more thoroughly during the next round of review and assessment. For Copeland Borough Council:

- The following new industrial processes commenced operation during the period 1 January 2007 to 31 March 2008.
  - Petrol unloading: Henry Graham, Bridge End Garage, Egremont – Feb. 2007
  - Petrol unloading: Crossfield Garage, Leconfield Street, Cleator Moor – Apr. 2007
  - Petrol unloading: Jubilee Garage, North Road, Egremont – Jun. 2007
  - Dry Cleaners: Lakeland Dry Cleaners, Church Street, Whitehaven – Feb. 2008
  - Lead melter: Sellafield Ltd, Sellafield – Mar. 2008
- No new landfill or quarries with nearby relevant exposure have been granted planning permission.
- There have been no new developments which may impact on air quality, by causing an increase in traffic flow since the previous Progress Report. The construction of the Distington bypass, to the west of the A595, commenced during 2006 causing a potential increase in heavy goods vehicles on the A595 delivering aggregate to the site from Eskett Quarry. When complete, the bypass will divert traffic from the A595 between Distington and Howgate, thus reducing congestion in the village of Distington and improving air quality. A new monitoring point was introduced at the Castle Inn in Distington in December 2006, which recorded NO_2 air concentrations of 35 $\mu g\ m^{-3}$. The Distington bypass will be considered further during the next Updating and Screening Assessment.

5. Discussion and conclusions

5.1 Comparison to NAQS objectives

Three of the pollutants monitored in the Borough of Copeland are below the NAQS objectives (NO_2, SO_2 and benzene) and are, therefore, considered to be present in concentrations at which adverse health effects are either not observed or in the case of benzene represent a very small risk to health. It has been noted, however, that even though the recorded concentrations of these three pollutants averaged over the past 12 months are well below the NAQS objectives, there are still instances where the monthly-averaged results are quite high. In such cases, attention should be focussed on reducing the emissions of the pollutants in question in the vicinity of the appropriate monitoring site if at all possible.

The exception to this is O_3, where annual concentrations close to the proposed objective limit of 100 $\mu g\ m^{-3}$, and considerably greater than EU objective of 18 $\mu g\ m^{-3}$ have been recorded since 2000. Because no directly comparable NAQS objective is available, the comparison made between annual average concentrations and 97th percentile of 8-hour mean concentrations is approximate and should only be used as a guide.

As discussed in Section 2.4.3 above, sources of O_3 in the atmosphere are very hard to control as O_3 results from both natural and anthropogenic sources and it is capable of being transported over long distances.

5.2 Comparison to Airviro modelled concentrations

Although not required as part of a Progress Report, dispersion model calculations of NO_2 were undertaken using the Airviro Air Quality Management System. This is intended to update previous dispersion model studies performed as part of Copeland B.C.'s 2006 Progress Report. The methodology and results are presented in Appendices B and C, respectively. The calculations used industrial emission rates for 2006 from the Environment Agency web site[7], and were validated using the 2006 diffusion tube data.

Annual average air concentrations of NO_2 are presented in Figures B5 modelled at a 1000 m grid resolution for the whole map area and in Figure B6 for Whitehaven and the surrounding area modelled at a 250 m grid resolution. A maximum annual average air concentration of 23 $\mu g\ m^{-3}$ at Scotch Street, Whitehaven area was predicted, which is less than the NAQS objective of 40 $\mu g\ m^{-3}$.

5.3 Conclusions

The results of the air quality monitoring programme in the Borough of Copeland show that, in general, the concentrations of all pollutants being monitored are below values at which adverse health effects are likely to occur. The general trend for all pollutants, with the exception of ozone, is for a continued decline in ambient concentrations, although NO_2 air concentrations of 35 $\mu g\ m^{-3}$ were recorded at the new monitoring point in Distington due to congestion caused by construction of the Distington Bypass.

[7] http://www.environment-agency.gov.uk/

6. References

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7. Tables

Table 1: Comparison of yearly average monitored NO_2 concentrations in Copeland during 2006 and 2007 ($\mu g\ m^{-3}$) and projected concentrations for the year 2010.

LOCATION	ADJUSTED MEAN * 2007 $\mu g\ m^{-3}$	ADJUSTED MEAN 2006 $\mu g\ m^{-3}$	% CHANGE 2006 to 2007	PROJECTED MEAN † 2010 $\mu g\ m^{-3}$
Kerbside Sites (9)				
4 Holyoak, Beckermet	8.8	10.4	-15%	7.9
55/56 Lowther St, Whitehaven	21.8	22.2	-2%	19.4
Esso Service Station, Holmrook	10.3	12.9	-20%	9.1
Kings Head Hotel, Bootle	17.3	20.1	-14%	15.4
Muncaster Castle	18.2	18.4	-1%	16.2
Council Centre, Millom	17.4	20.4	-15%	15.5
The Globe, Gosforth	12.1	15.7	-23%	10.8
Police Station, Scotch St	31.2	34.4	-9%	27.8
Tourist Information, Egremont	18.0	19.0	-5%	16.0
Civic Hall, Whitehaven	26.0	26.3	-1%	23.4
Distington A595 Castle Inn	35.8	N/A	N/A	31.8
Intermediate Sites (5)				
1 Chapel St, Distington	10.5	11.9	-12%	9.7
6 Todholes Rd, Cleator Moor	8.5	10.0	-15%	7.8
Bootle Station, Bootle	7.0	7.6	-8%	6.4
Egremont Cemetry	14.0	14.8	-5%	12.8
St Bridgets Presbytry, Egremont	9.2	10.5	-12%	8.5
Background Sites (8)				
21 Scafell Crescent, Seascale	8.3	8.0	4%	7.6
4/5 Robinson Row, Millom	9.0	10.1	-11%	8.3
Calder Hall Farm	8.1	8.6	-6%	7.5
Fire Station, Main St, Whitehaven	10.7	10.8	-1%	9.8
Greendale Guesthouse, Wasdale	4.3	5.4	-20%	4.0
No. 2 The Crescent, Thornhill	8.6	11.4	-25%	7.9
Playground, Ennerdale School	6.5	7.8	-17%	6.0
Bootle Station, Bootle	7.0	7.6	-8%	6.4

2006 and 2007 data with diffusion tube adjustment factors of 1.11 (2006) from Lutman 2007 and 1.01 (2007) applied from UWE website:
http://www.uwe.ac.uk/aqm/review/mguidance.html#Bias%20Adjustment.

† Uses a projection factor for 2007 to 2010 of 0.92 (background and intermediate sites) and 0.89 (roadside sites). The projection factors are from the Year Adjustment Calculator v2.2a
http://www.airquality.co.uk/archive/laqm/tools.php?tool=year04

Table 2: Comparison of annual average and 99.9th percentile of 15-minute means (µg m^{-3}) of SO_2 monitored in 2006 and 2007.

Location	**2007**		**2006**		**% Change 2006 to 2007 for annual average values**
	Annual Mean (µg m^{-3})	**99.9th percentile of 15 min means (µg m^{-3}) †**	**Annual Mean (µg m^{-3})**	**99.9th percentile of 15 min means (µg m^{-3}) †**	
Seacliffe Garage Kells	3.0	41	3.8	52	-22%
Kells Primary School	1.4	18	1.8	25	-25%
Calder Farm, Seascale	1.6	22	2.0	27	-20%
Todholes Rd, Cleator Moor	1.9	26	1.8	25	7%
Mill Hill, Cleator Moor	2.1	29	1.1	15	95%
Tourist Information, Egremont	1.1	15	1.3	18	-15%
Church House, Egremont	1.6	22	1.9	26	-14%
How Farm, Seascale	1.5	21	1.7	23	-10%

† Derived using the methodology of Pratt and Dalton (2000)

Table 3: Annual average benzene concentrations in Copeland in 2006 and 2007 (µg m^{-3})

Location	**2007** µg m^{-3}	**2006** µg m^{-3}	**% Change 2006 to 2007**	**PROJECTED MEAN** † **2010** µg m^{-3}
Brantano entrance, Whitehaven	0.66	0.90	-27%	0.60
Tesco car park, Whitehaven	0.92	0.98	-6%	0.84
Castle Inn, Distington	0.67	0.85	-21%	0.61
2A Main Street, Distington	1.01	1.23	-18%	0.93
Bergendal, Gilgarran Rd, Distington	0.34	0.73	-54%	0.31
20 Commonside, Distington	0.39	0.43	-9%	0.36
Layby Clint's Quarry, Egremont	0.91	1.11	-18%	0.83
Blackbeck Hotel	0.34	0.93	-64%	0.31
Fire Station, Hensingham	0.48	1.09	-56%	0.44
Hensingham Road	0.61	0.94	-35%	0.56
15 Countess Road, Whitehaven	0.46	0.47	-1%	0.42
13 Loop Road North, Whitehaven	0.80	0.89	-10%	0.73
Police Station, Millom	0.55	1.49	-63%	0.50
ESSO Petrol Station, Millom	0.65	1.11	-42%	0.59
Whicham Church	0.38	0.51	-25%	0.35

† Calculated using a projection forward to 2010 of 0.647/0.709 (from Box 3.4, P 3-6 of TG(03)) http://www.defra.gov.uk/environment/airquality/local/guidance/pdf/laqm-tg03.pdf.

Table 4: Annual average ozone concentrations in Copeland in 2006 and 2007($\mu g\ m^{-3}$)

Location	**2007** $\mu g\ m^{-3}$	**2006** $\mu g\ m^{-3}$	**% Change 2006 to 2007**
86 George St, Whitehaven	64.8	65.7	-1%
Fire Station, Main St, Whitehaven	79.9	83.7	-5%
1 Chapel St, Distington	77.4	81.7	-5%
4/5 Robinson Row, Millom	72.7	77.5	-6%
Tourist Information, Egremont	61.0	57.8	6%
Playground, Ennerdale School	75.5	77.7	-3%
Esso Service Station, Holmrook	63.0	67.3	-6%
N. T. Campsite, Wasdale	88.8	102.7	-14%
Lingmell Nose, Scafell	Not monitored	209.4	N/A
Summit of Scafell Pike	Not monitored	161.3	N/A

Table 5: Comparison of annual mean O_3 concentrations with 97th percentile of 8-hour mean concentrations

	Site	Type	97%ile of 8-hour means ($\mu g\ m^{-3}$)*	Annual Average ($\mu g\ m^{-3}$)†
5 highest concentrations	Somerton	Rural	128	58
	Lullington Heath	Rural	120	58
	Yarner Wood	Rural	116	80
	London Teddington	Urban Background	112	42
	Rochester	Rural	110	42
5 at objective level	Straith Vaich	Remote	100	70
	Aston Hill	Rural	100	62
	London Bexley	Suburban	100	36
	Redcar	Suburban	100	46
	Southampton Centre	Urban Centre	100	36
5 lowest concentrations	London Bloomsbury	Urban Centre	70	20
	London Lewisham	Urban Centre	68	20
	Bradford Centre	Urban Centre	68	26
	Bury Roadside	Roadside	66	16
	London Marylebone Road	Kerbside	48	12

* Data from The Air Quality Strategy for England, Scotland Wales and Northern Ireland (DETR 2000)

† Data from the National Air Quality Information Archive website

8. Figures

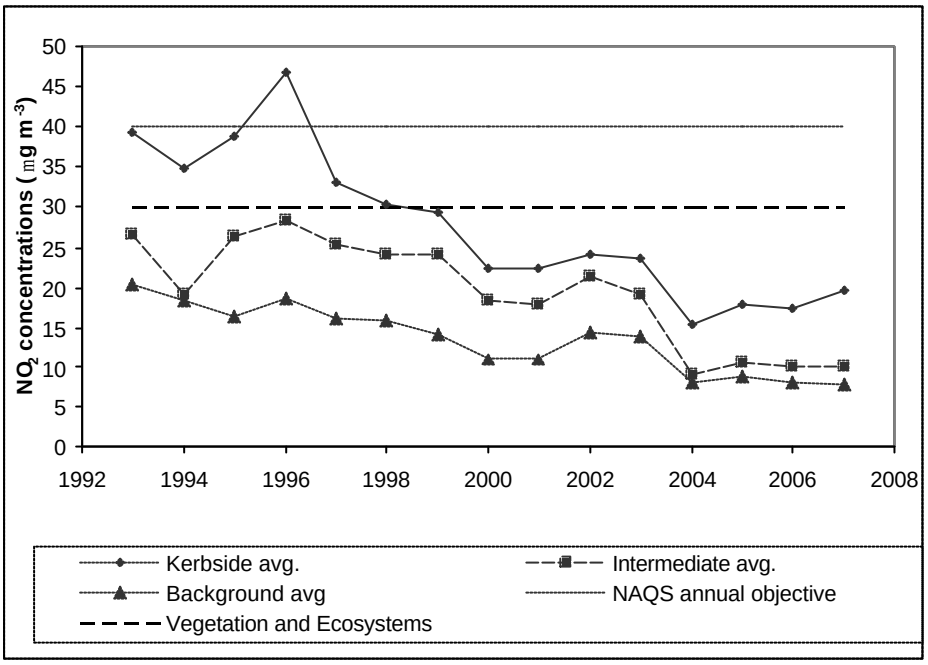

Figure 1: Annual average NO_2 diffusion tube measurements from 1993 – 2007 for kerbside, intermediate and background sites.

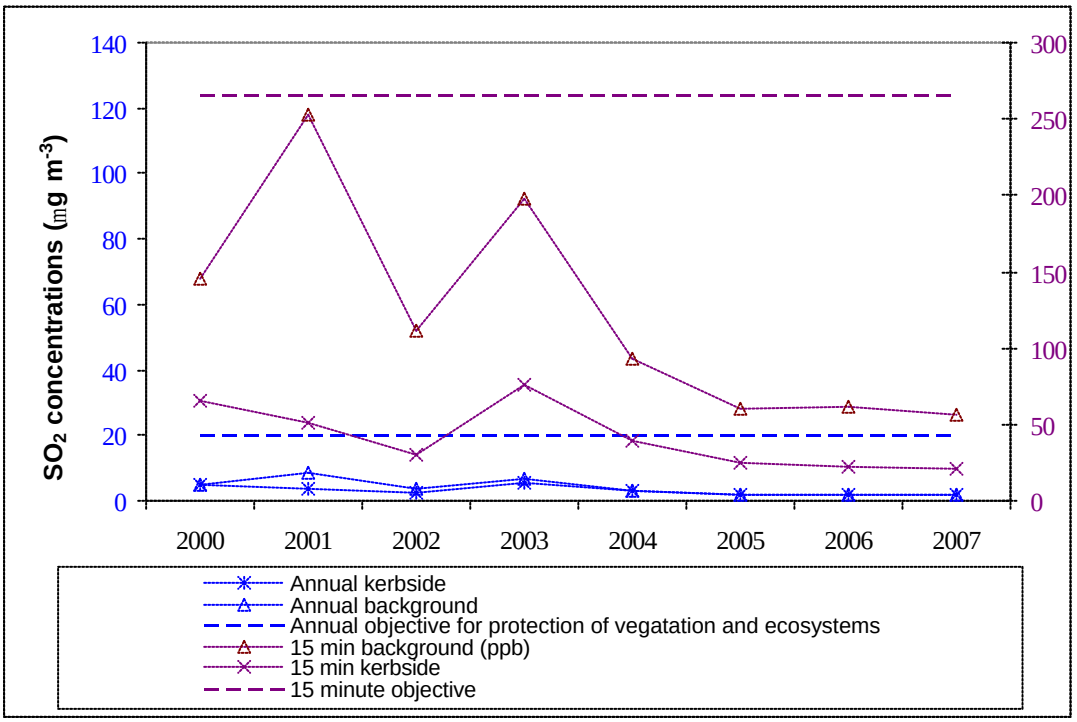

Figure 2: Annual average and 15 minute SO_2 diffusion tube measurements from 2000 – 2007 for kerbside and background sites.[8]

[8] Predicted 15 minute averages calculated following the method of Pratt and Dalton (2000).

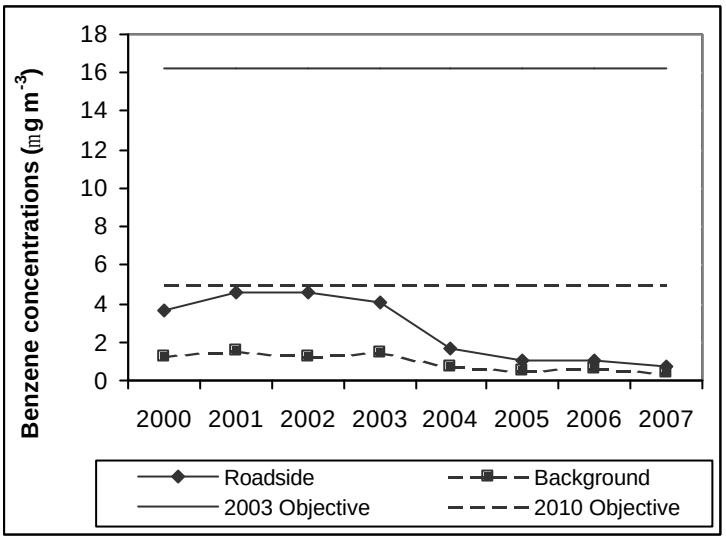

Figure 3: Annual average benzene diffusion tube measurements from 2000 – 2007 for kerbside and background sites.

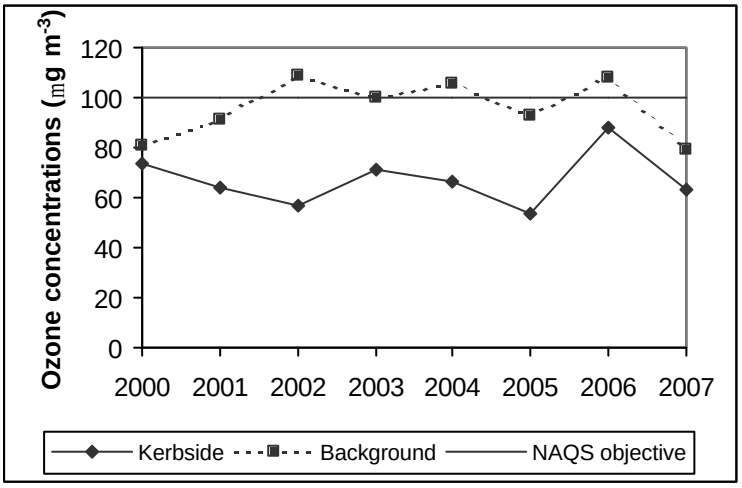

Figure 4: Annual average ozone diffusion tube measurements from 2000 – 2007 for kerbside and background sites.[9]

[9] The overall average for 2007 is lower than for previous years. Annual average O_3 results for 2000-2006 included Lingmell Nose and the Summit of Sca Fell which are not monitored for 2007 onwards. These locations are at higher altitudes and measured higher concentrations of O_3 than tubes at lower altitudes.

Appendix A: Maps of the monitoring sites in Copeland

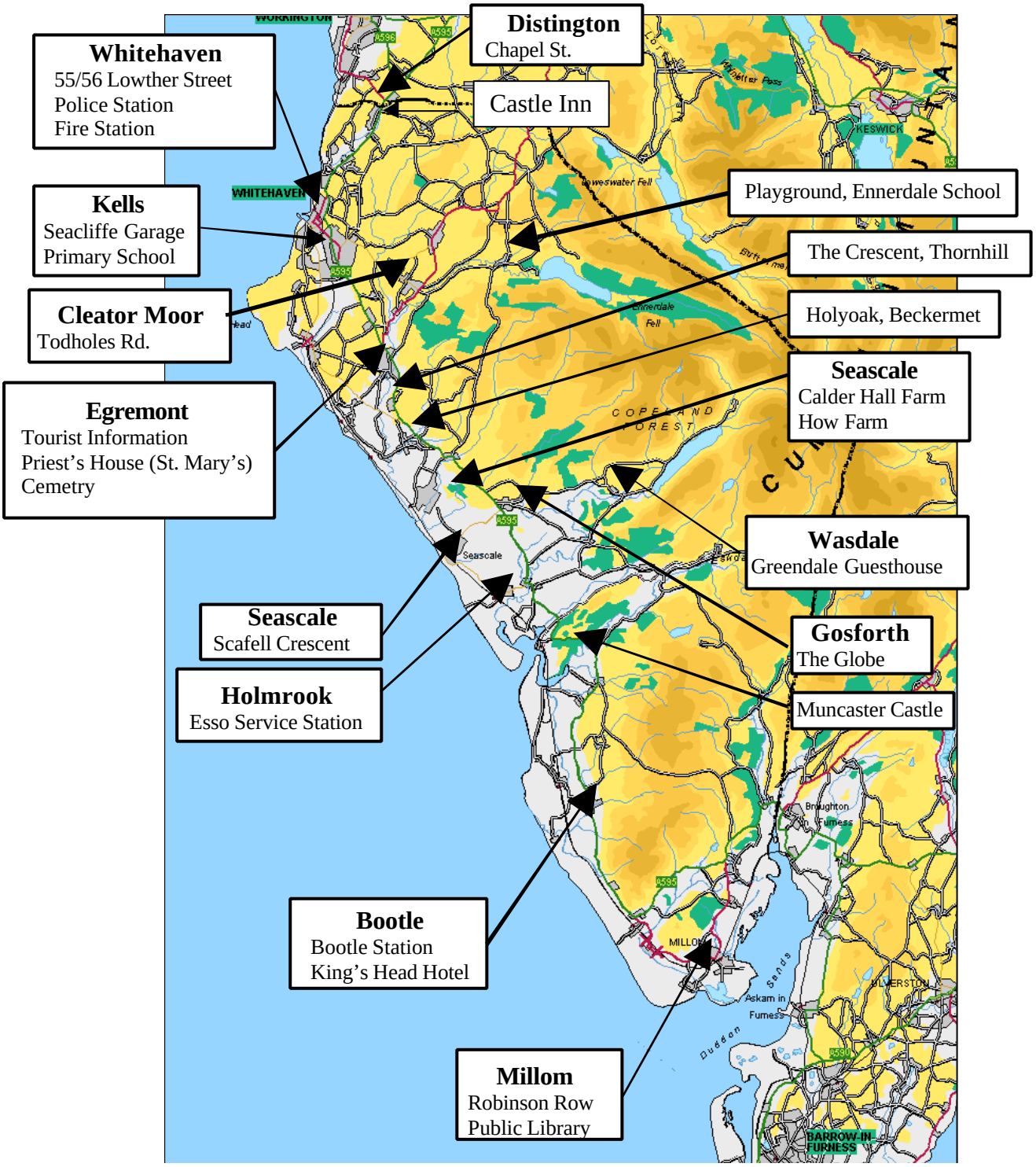

Figure A1: Distribution of NO_2 monitoring sites in Copeland

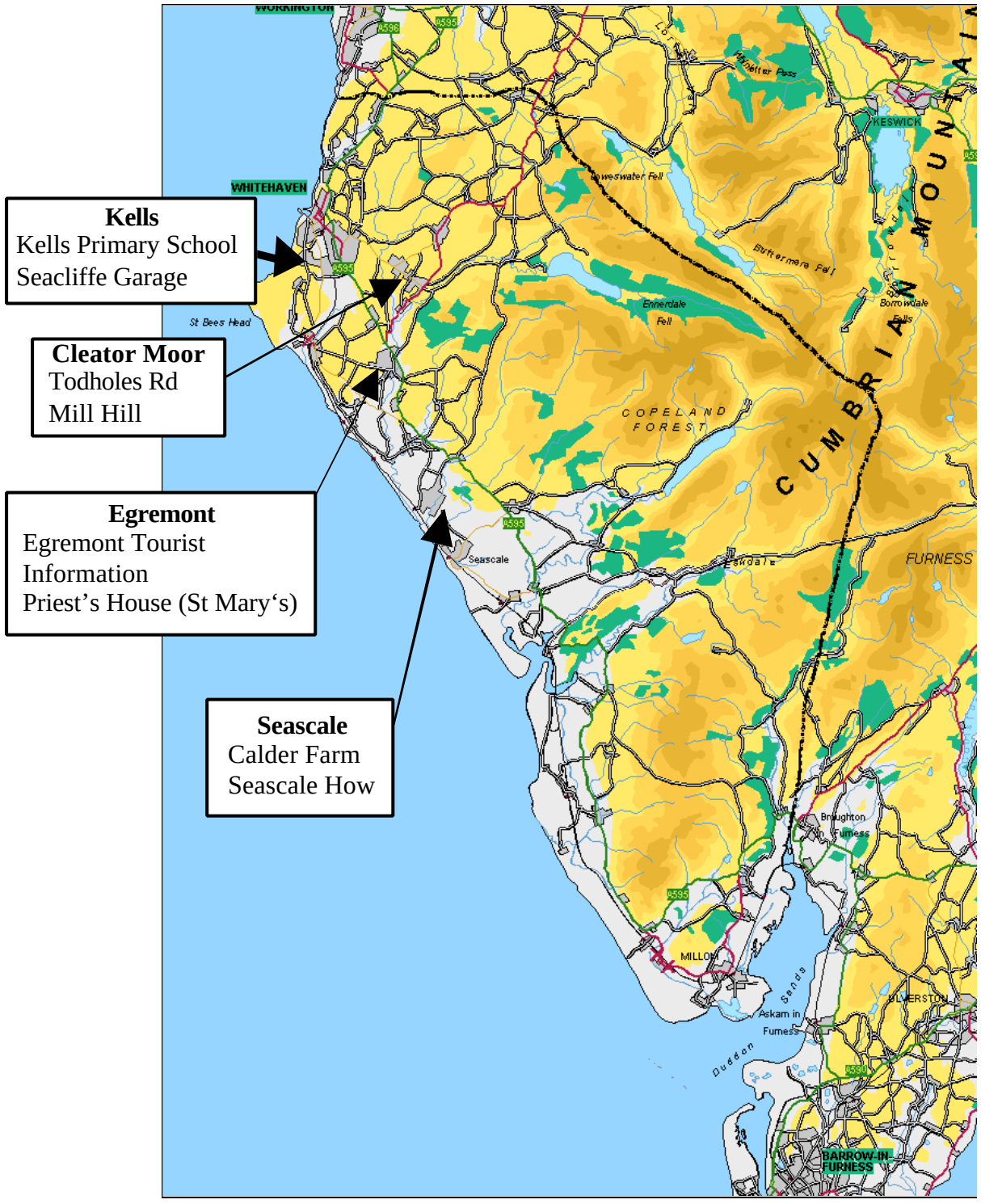

Figure A2: Distribution of SO_2 monitoring sites in Copeland

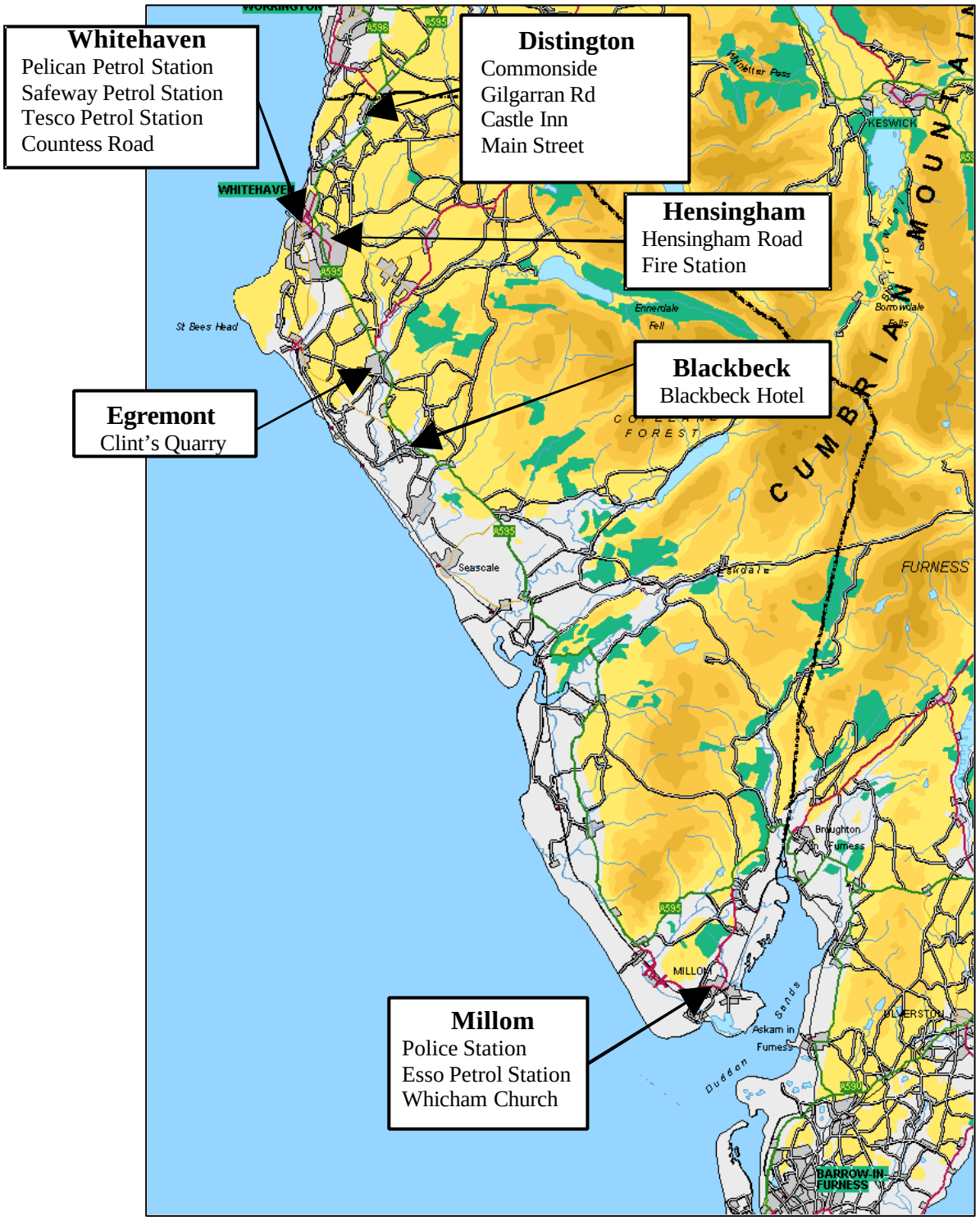

Figure A3: Distribution of benzene monitoring sites in Copeland

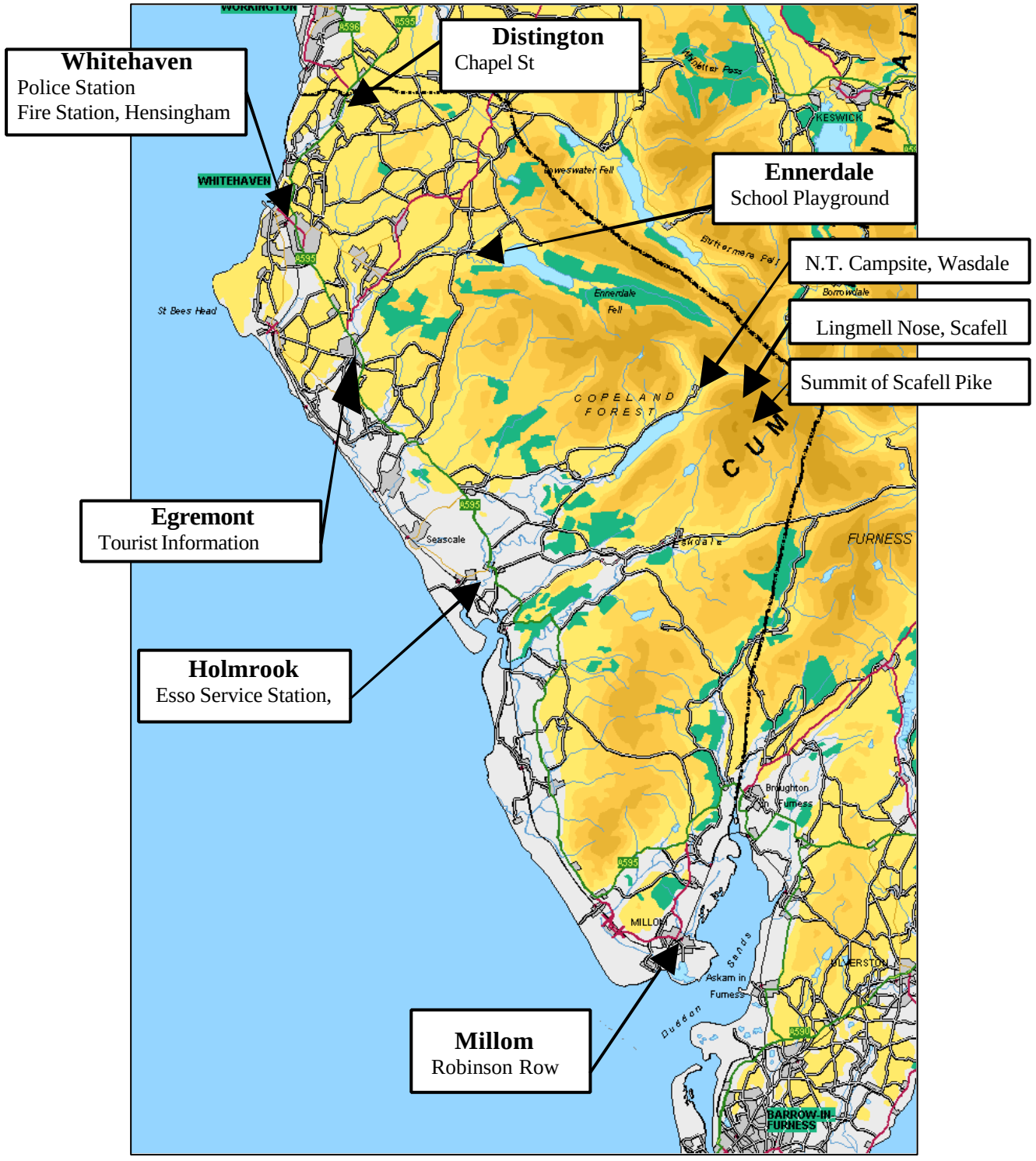

Figure A4: Distribution of O_3 monitoring sites in Copeland

Appendix B: Dispersion modelling using Indic Airviro

1. Introduction

This section describes dispersion modelling studies of NO_2 which are intended to update previous dispersion model studies performed by Lutman (2007) as part of Copeland B.C.'s 2006 Progress Report.

1.1 Methodologies

The Indic Airviro air quality management system was used to model the emissions and atmospheric dispersion of NO_2. The Indic Airviro system is described by Hill and Simpson (2000). The following input data was used in the modelling system:

- Emissions of pollutants from grid, road and point sources are modelled in the emissions database (EDB)
- Topography data on terrain height, surface roughness and percentage of urban area / open area / forest in each grid cell
- Meteorological data (wind speed, wind direction, standard deviation of the wind direction, temperature and temperature difference with respect to height)

The modelling studies were conducted in three stages as follows:

- Low resolution regional modelling studies were undertaken to identify areas where hot spots were likely to occur. (In addition, these were used to estimate background concentrations of NO_x) as described in section 1.2).
- High resolution modelling studies over a local area were conducted to compare the expected pollutant concentrations with the NAQS objectives in areas where the low resolution modelling studies indicated hot spots of NO_2.
- Validation studies for NO_2 were carried out by comparing modelled concentrations with a selection of the available diffusion tube monitoring data.

1.1.1 Choice of model

The Airviro Air Quality Management system contains three atmospheric dispersion models that could be applied in an air quality assessment. These are:

- Grid model
- Gauss model
- Canyon model

The modelling studies contained in this report were assessed using the Gauss and Canyon models. The Gauss model is particularly suited to local-dispersion studies (SMHI, 1997) and was therefore considered appropriate for use in the Copeland area. The Eulerian Grid model is designed for application over long ranges and where three-dimensional wind fields are required and was therefore not appropriate for modelling over the Copeland area. The Canyon model is designed for use on individual streets with tall buildings at either side. This model was applied to 2 streets in Whitehaven, Lowther Street and Scotch Street, using estimated building height data.

1.1.2 Meteorological data

The meteorological data used in the modelling assessments were derived from 10 years worth of meteorological data (from the end of 1995 to the end of 2005) from the meteorological mast on the British Nuclear Group (Sellafield) Ltd. site (approximately 10 miles south of

Whitehaven), supplied courtesy of BNGSL. A statistical dataset was compiled from hourly time series data from the Sellafield Meteorological Station using the Airviro KLMSTAT program, which analyses meteorological data over 60 wind direction classes and 6 air-stability classes. The use of statistical meteorological data based on 11 years worth of real data avoids possible annual variations that can be present if real data for just one specific year are used.

1.2 Background concentrations

Airviro models pollutant concentrations solely from sources within the map area being investigated. However, contributions of the pollutant from sources outside the map area being modelled must also be considered, this is classed as the background concentration. Dispersion modelling studies for the Copeland area were undertaken in two ways; either "whole map" studies or "local area" studies. The method of calculating a background concentration of NO_2 for each of these modelling scenarios is described below.

1.2.1 Background concentrations for "whole map" dispersion modelling studies

For the "whole map" studies, the background concentration consists of any input of the pollutant from sources not already contained within the EDB, resulting for example from large-scale air movements across the whole country (Figure B1). For all of the Copeland dispersion modelling studies, background concentrations (from the NETCEN website and including sources of the pollutant from the whole country) were selected at 3 locations where local sources would have a low contribution and averaged to give a representative value.

The modelled area in Figure B1 is the whole EDB map area. The shaded area represents the source of the background concentration (i.e. anywhere outside the modelled area) and includes pollutant input from nation-wide sources. By selecting air concentrations from the NETCEN website as described above and subtracting the Airviro predicted concentration at the same locations[10], the average background concentration resulting from area 1 was estimated.

1.2.2 Background concentrations for "local area" dispersion modelling studies

In order to calculate dispersion using a sufficiently high-resolution grid, it is necessary to zoom into a smaller model domain (see Figure B2). For "local area" modelling studies, the Airviro model again only considers input of the pollutant from sources within the map area being modelled. Therefore, consideration has to be given to input of the pollutant from sources within the EDB, but outside the local area being modelled. Figure B2 shows the two contributions to the background that should be considered for the local area studies. The gridded pollutant concentrations in the local area being modelled (derived solely from the sources within the local area) are subtracted from the gridded concentrations of the pollutant derived from sources within the whole EDB. The resulting concentrations are then added to the background for the "whole map" area derived from long-range, nation-wide sources, as described in section 1.2.1.

The modelled area in Figure B2 is a local area within the whole EDB map. Area 1 represents the source of the background concentration for the whole EDB (as detailed in section 1.2.1). Area 2 represents the source of the background concentration within the EDB, but outside the modelled area. The contributions from Areas 1 and 2 must be summed to provide a total background concentration for the local modelled area.

[10] Air concentrations calculated across the entire EDB were calculated using a 1000 m x 1000 m resolution grid.

1.3 Model validation

The uncertainty associated with modelling results can be assessed by comparison to monitoring data from a site within the modelled area. It is suggested in the NAQS guidance document TG3(00), that an acceptable level of uncertainty for dispersion modelling results is ± 50%. Modelling results are unavoidably subject to some degree of uncertainty as dispersion models are designed to provide a simple representation of a highly complex real environment. Some of the sources of uncertainty in dispersion modelling include:

- Input Data Errors
- Insufficient data
- Meteorology
- Emission data
- Atmospheric Turbulence
- Model Simplifications
- Future weather
- Spatial and Temporal Averaging

The uncertainty does not undermine the validity of the modelling results, but it does emphasise the need for validation studies. Miller and Hively (1987) in a review of validation studies for the Gaussian plume atmospheric dispersion model state that:

> *"…when the model has the proper parameters, annual average air concentrations over flat terrain can be predicted within a factor of 2 to 4."*

The results from the Copeland dispersion modelling studies were compared to monitoring data from within the Copeland Borough in order to assess the uncertainty associated with the modelling results. The uncertainties are described in the following results section.

1.4 Dispersion modelling assessment

The Airviro Gauss model was used to assess the annual average NO_x concentrations on a 1000 x 1000 m grid across the entire model domain in order to identify any potential "hot-spots". The model was then used to assess NO_x concentrations on a more local scale in the vicinity of the identified "hot-spots" at a higher grid resolution of 250 m x 250 m.

As stated in the guidance document TG4(00) (DETR 2000), the annual mean objective for NO_2 is more stringent than the short period objective, therefore, the annual mean was assessed in this study.

Annual average background NO_x concentrations (for 2004) were taken from the DETR website, the values of which are shown in Table B1. The Derwent and Middleton (1996) equation was applied to determine concentrations of NO_2 from NO_x.

1.5 Model validation results

The Copeland area was modelled at a grid resolution of 250 m x 250 m in order to assess the uncertainty associated with the modelling results. NO_2 concentrations predicted by Airviro in 2006 were compared to those monitored using NO_2 tubes at 12 locations.

Plotting measured NO_2 concentrations from 12 sites across the area measured in 2006 against those predicted by the model for 2006 and fitting the data to a linear model, then setting the y-intercept to zero revealed a relationship between the two, with a slope coefficient of 0.39 (Figure B3). The poor correlation is partly due to an underestimation of roadside air concentrations.

In order to account for any street canyon effects, the Airviro Canyon model was run for Scotch Street and Lowther Street, Whitehaven, using the input parameters shown in Table B2. The predicted additional contribution to the air concentrations due to street canyon effects are given in Table B2. These concentrations were added to the background concentrations predicted by the Gauss in Table B3 and Figure B4.

Corrected NO_2 concentrations predicted by the dispersion model were compared with diffusion tube estimates of the air concentrations of NO_2 in Table B3 and Figure B4, with a slope coefficient of 0.66. The Root Mean Square (RMS) difference was determined showing that the uncertainty limits for the dispersion model were $\pm$ 6.3 $\mu g\ m^{-3}$.

The greatest underpredictions were for the Tourist Information centre, Egremont (64%) and Egremont Cemetery (51%). 83 % of the model predictions within +/- 50 % of the measured values. Airviro underpredicted air concentrations in all cases except for Lowther Street, which over-predicted air concentrations by 3 %.

1.6 Comparison with NAQS objectives

Annual average air concentrations of NO_2 are presented in Figures B5 modelled at a 1000 m grid resolution for the whole map area and in Figure B6 for Whitehaven and the surrounding area modelled at a 250 m grid resolution. A maximum annual average air concentration of 23 $\mu g\ m^{-3}$ at Scotch Street, Whitehaven area was predicted, which is less than the NAQS objective of 40 $\mu g\ m^{-3}$.

2. References

Derwent R. G. and Middleton D. R. (1996). An empirical function for the ratio $[NO_2]$:$[NO_x]$, Clean Air 26: 57-60.

Hill R. and Simpson K. (2000). Copeland BC Airviro System-Dispersion Modelling Report 990306/07, Westlakes Scientific Consulting.

Miller C. W. and Hively L. M. (1987). A review of validation studies for the Gaussian plume atmospheric dispersion model. Nuclear Safety 28(4): 522 – 531.

SHMI (1997). Airviro: An integrated system for air quality management Airviro specification v2.20 Swedish Meteorological and Hydrological Institute, Sweden.

DETR (2000). Part IV of the Environment Act, 199 Local Air Quality Management. Technical Guidance LAQM TG(03). http://www.defra.gov.uk/environment/airquality/local/guidance/pdf/laqm-tg03.pdf.

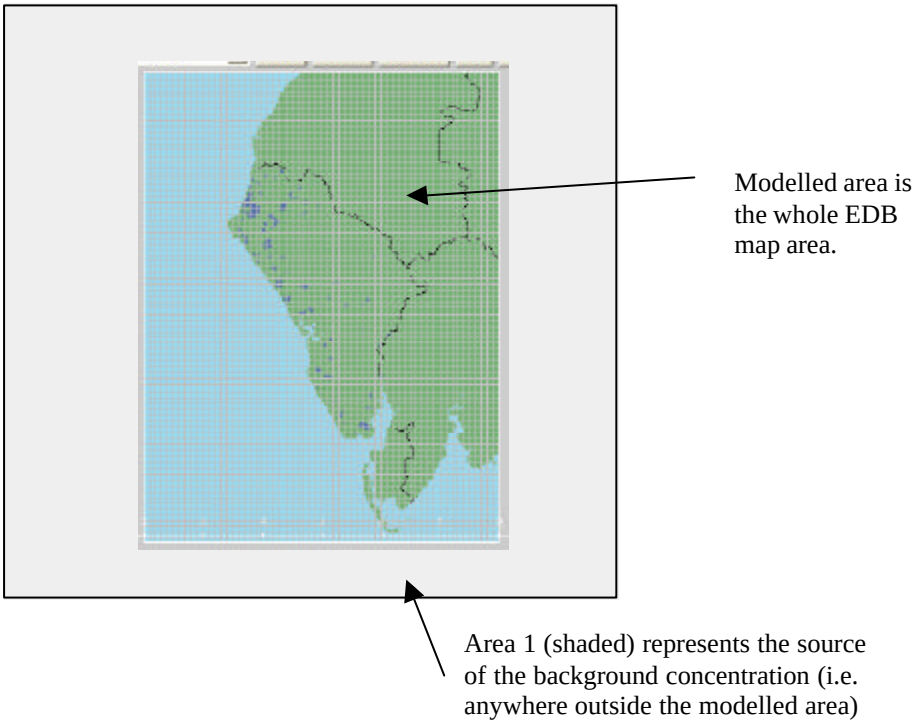

Figure B1: Background concentrations for "whole map" dispersion modelling studies

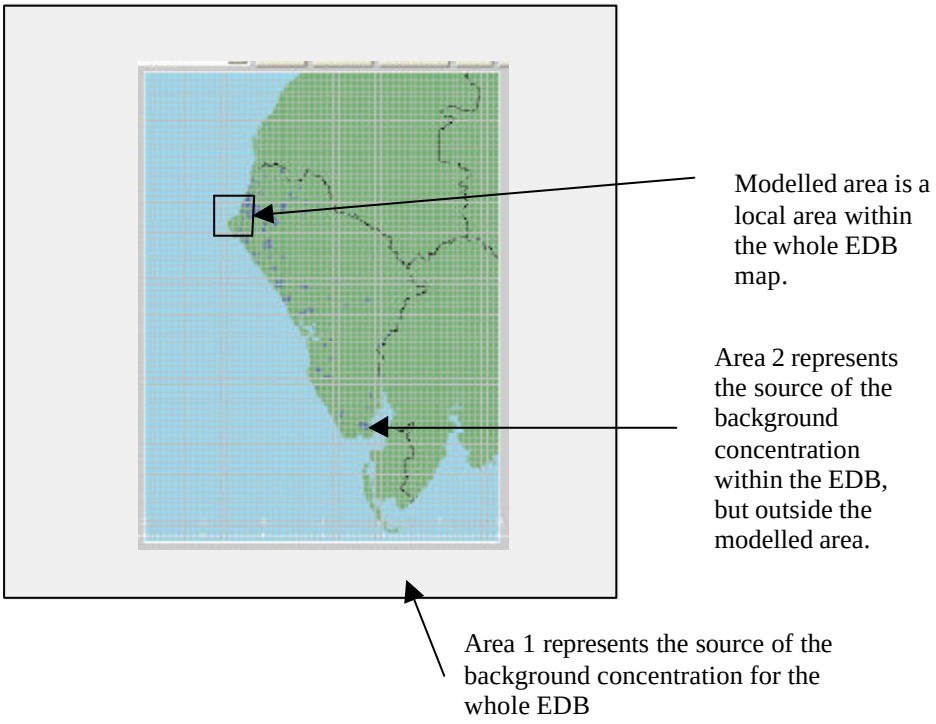

Figure B2: Background concentrations for "local area" dispersion modelling studies.[11]

[11] In order to calculate background concentrations, a local area model grid resolution of 1000 m x 1000 m was used.

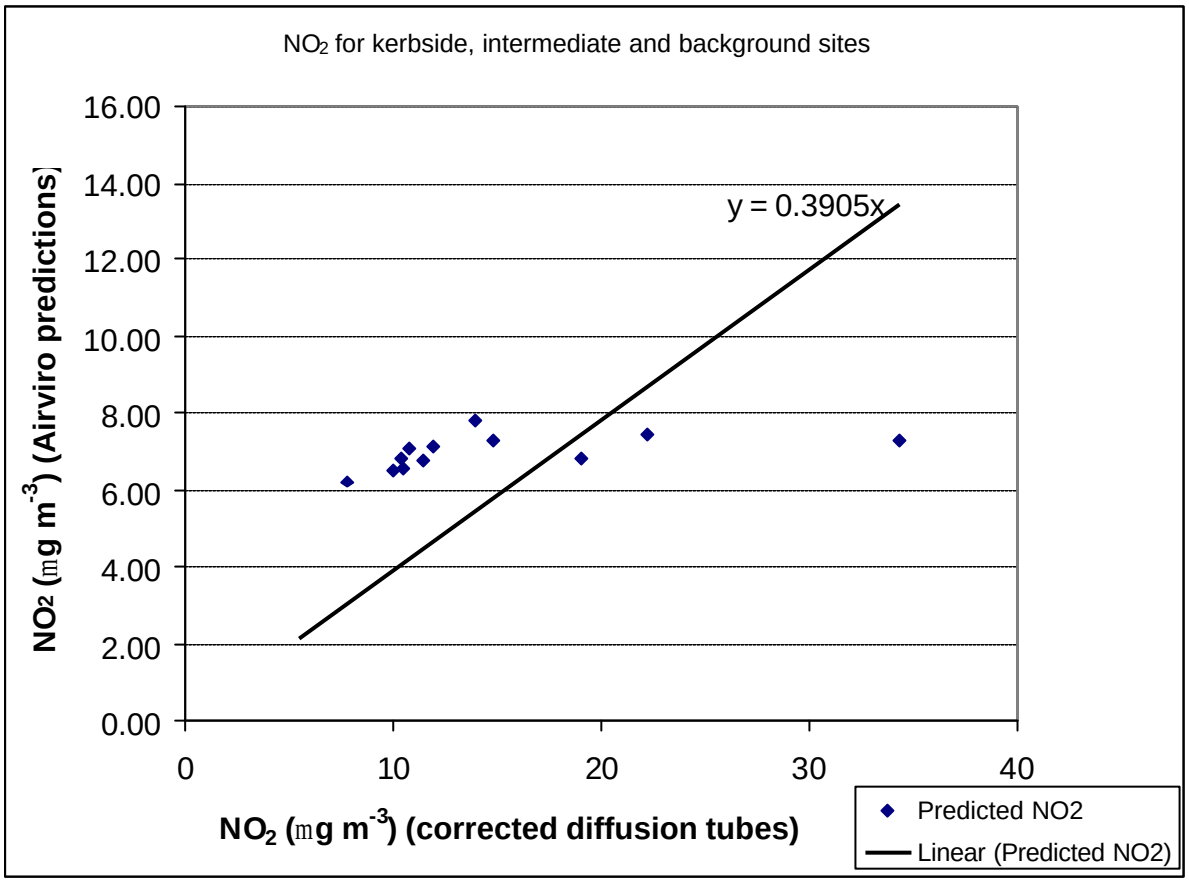

Figure B3: Relationship between predicted and measured NO_2 concentrations during 2006 for all locations. Street canyon effects are not included.

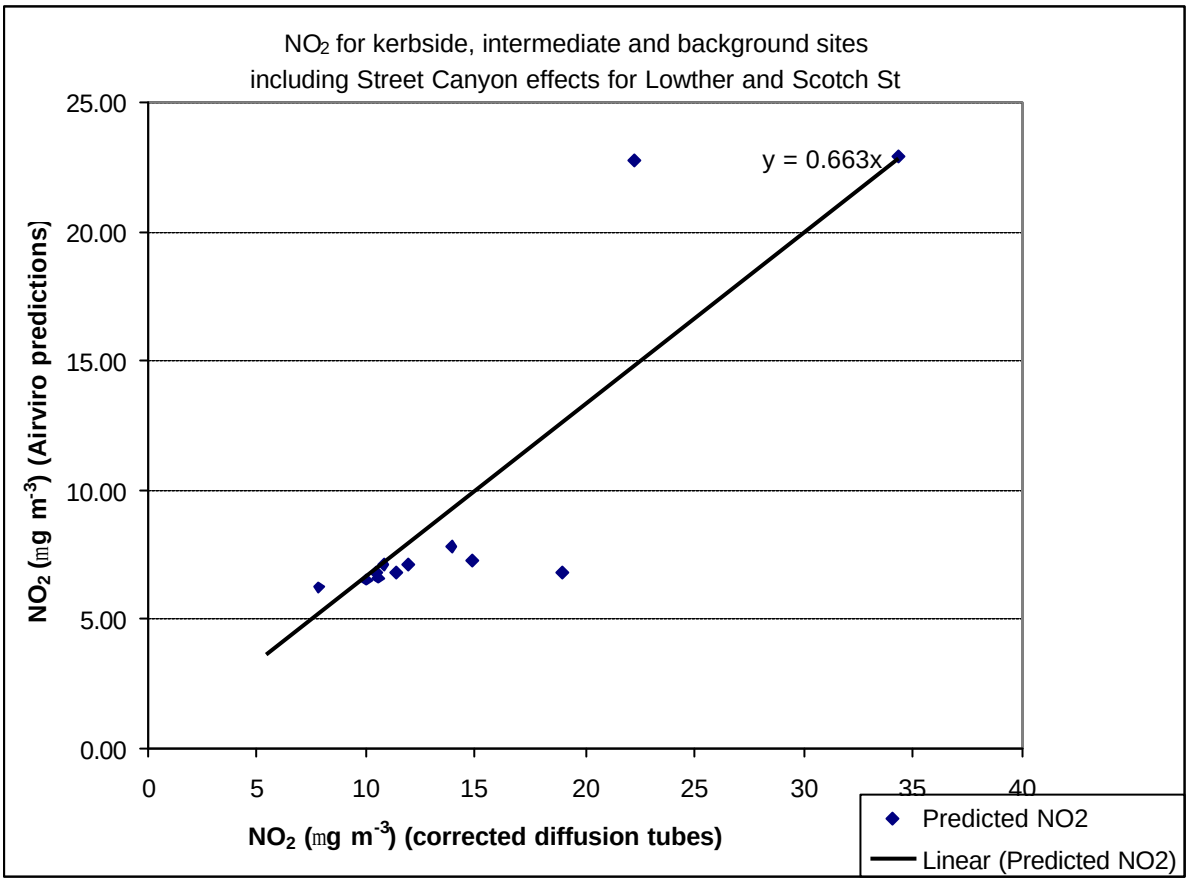

Figure B4: Relationship between predicted and measured NO_2 concentrations during 2006 for all locations. Street canyon effects are included for Lowther St. and Scotch St., Whitehaven.

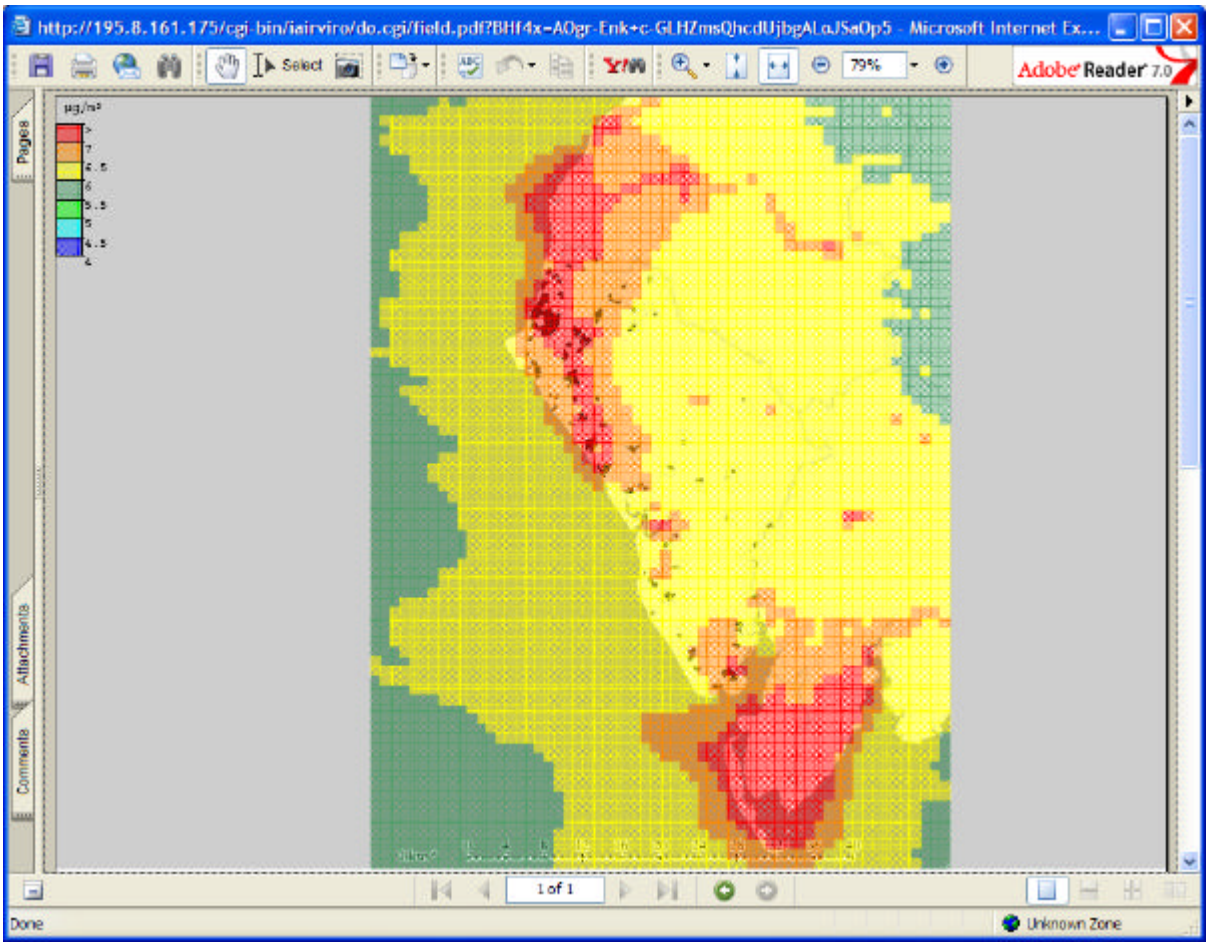

Figure B5: Annual average air concentrations of NO_2 across Copeland and adjacent Boroughs (using 10 years of meteorological data). [12]

[12] NO_x air concentrations due to all sources throughout the entire EDB were calculated using a 1km x 1km resolution grid. NO_2 concentrations are calculated from the modelled NO_x using the Derwent Middleton equation, including a national background contribution of 7.5 µg m^{-3} .
$NO_2 = 4.13706-(NO_x +7.5)*(2.6415-5.2559*\log(NO_x +7.5)+2.652*\log(NO_x +7.5)^2-0.4058*\log(NO_x +7.5)^3)$

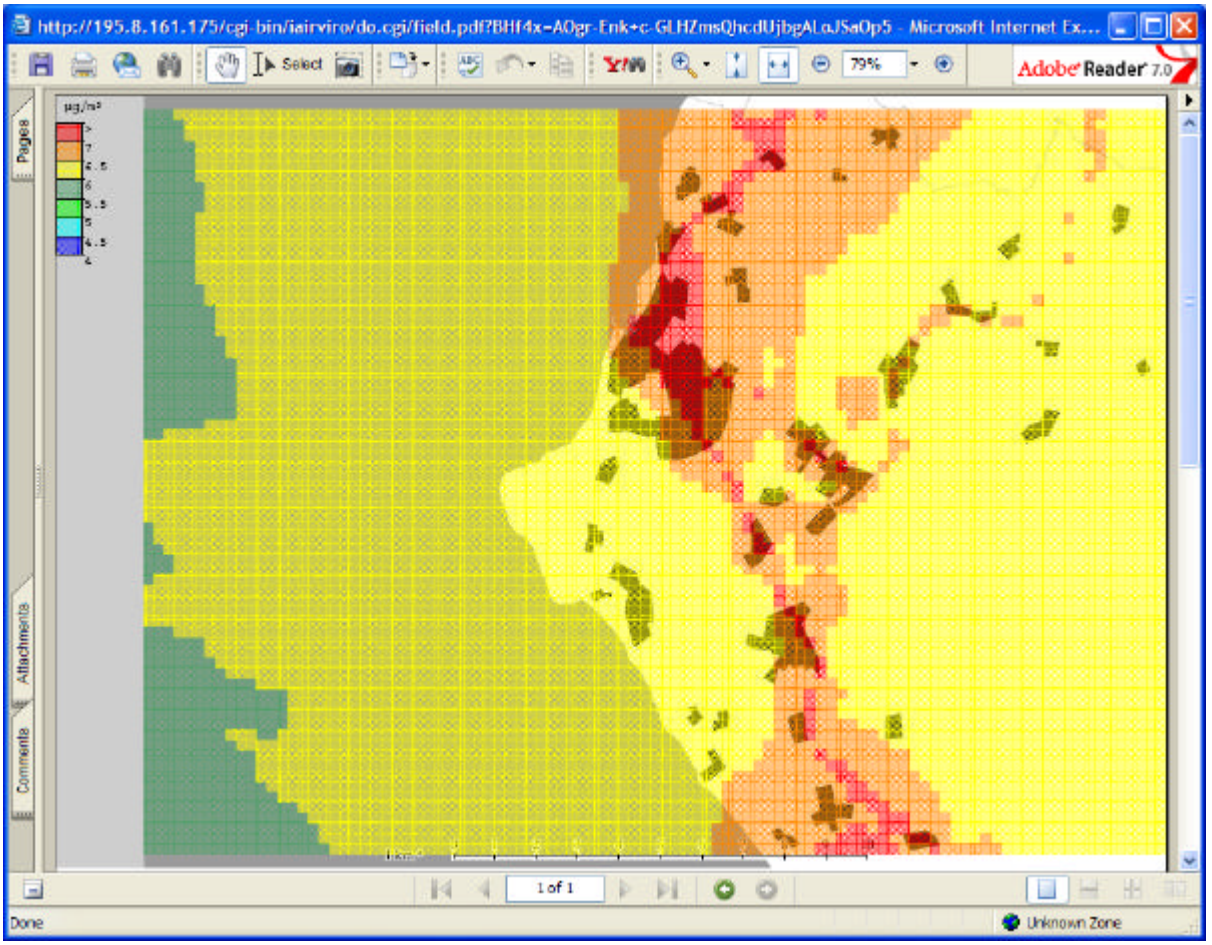

Figure B6: Annual average air concentration of NO_2 at Whitehaven (using 10 years of meteorological data).[13]

[13] NO_x air concentrations were predicted by combining background concentrations calculated using a 1000 m x 1000 m grid and the local source contributions calculated using a 250 m x 250 m grid. NO_2 values were calculated using the Derwent Middleton equation assuming a national background contribution of 7.5. No street canyon effects included.

Table B1: Concentrations of NO_x used in the modelling study to estimate the 'National Background' contribution.

OS Easting (m)	OS Northing (m)	NO_x (µg m^{-3}) from UK Air Quality Archive website[14] for 2006	NO_x (µg m^{-3}) predicted using Airviro for 2006	Background concentration of NO_x (µg m^{-3})
320138	488673	8.46	0.945	7.51
321088	511801	7.11	0.497	6.62
320930	535564	9.05	0.554	8.50
Average national background concentration				7.54

Table B2 Input parameters for the Street Canyon Model[15]

	Scotch Street	Lowther Street
Dist between houses (m)	12	13
Height (m)	15	15
Street width (m)	10	10
Street direction clockwise (^{o} from North)	40	130
OS Coords (East and West)	297560 518123	297342 518155
Vehicles per day	6856	6628
speed kph	30	30
Predicted roadside concentration (µg m^{-3})	20	20
Receptor Height (m)	3	3

[14] http://www.airquality.co.uk/ Values were obtained for 2005 and adjusted using a factor of 0.96.
[15] Street width and house heights are estimated values

Table B3: Comparison between NO_2 concentrations predicted by Airviro and those monitored using NO_2 diffusion tubes in 2006 at 13 locations throughout Copeland.

Monitoring point	Monitor location		Modelled NO_x concentration (µg m^{-3})					Modelled NO_2 concentration [16] (µg m^{-3})	Monitored concentration (µg m^{-3})	% difference between modelled and monitored NO_2
	E	N	Local domain (point and road sources) (250 m grid resolution)	Regional domain (all sources) (1 km grid resolution)	Local EDB domain (all sources) (1 km grid resolution)	National background	Total concentration [17]			
Background										
4 Holyoak, Beckermet	301855	506755	0.2	1.7	0.6	7.5	8.9	6.8	10.4	34%
55/56 Lowther St, Whitehaven	297392	518113	1.2	2.9	2.4	7.5	29.0	22.7	22.2	-2%
Police Station, Scotch St, Whitehaven	297623	518208	7.2	3.3	2.9	7.5	29.2	22.9	34.4	33%
Tourist Information, Egremont	301080	510815	8.2	1.8	1.1	7.5	8.9	6.8	19.0	64%
Civic Hall Average	300442	522608	9.2	2.2	0.8	7.5	10.0	7.8	13.9	44%
Intermediate			10.2							
1 Chapel St, Distington	300558	523437	11.2	2.1	0.8	7.5	9.2	7.1	11.9	40%
6 Todholes Rd, Cleator Moor	302175	514658	12.2	1.6	0.9	7.5	8.6	6.5	10.0	34%
Egremont Cemetry	300860	511565	14.2	1.9	1.3	7.5	9.4	7.3	14.8	51%
St Bridgets Presbytry, Egremont	300965	510660	15.2	1.7	1.0	7.5	8.6	6.6	10.5	37%
Background										
Fire Station, Main St, Whitehaven	298970	517100	20.2	3.5	2.9	7.5	9.2	7.1	10.8	34%
No. 2 The Crescent, Thornhill	301168	508873	22.2	1.7	0.8	7.5	8.8	6.8	11.4	40%

[16] Modelled NO_2 concentrations calculated from modelled NO_x concentrations using the Derwent and Middleton (1996) equation.
[17] Total concentration of NO_x = [Local domain (point + road) + regional domain (all sources) – local domain (all sources) + National background] (except for Lowther St. and Scotch St. where local concentration is calculated using Street Canyon model.)

Monitoring point	**Monitor location**		**Modelled NO_x concentration (µg m^{-3})**					**Modelled NO_2 concentration [16] (µg m^{-3})**	**Monitored concentration (µg m^{-3})**	**% difference between modelled and monitored NO_2**
	E	**N**	**Local domain (point and road sources) (250 m grid resolution)**	**Regional domain (all sources) (1 km grid resolution)**	**Local EDB domain (all sources) (1 km grid resolution)**	**National background**	**Total concentration [17]**			
Background										
Playground, Ennerdale School	306990	515804	23.2	0.9	0.3	7.5	8.2	6.2	7.8	20%
Root mean square										6.3

Appendix C : The Airviro Copeland Emissions Database

This Appendix provides further details concerning the assumptions and input data used in the set up of the Emissions Database.

1. Road traffic Sources

1.1 Traffic speed and vehicle flow

Measured data for the speed of traffic and average daily traffic flow (AADT) on roads in the Copeland area were not available for all roads. Therefore, the speed of traffic and traffic flow on some road sections were assumed to be the same as those on the nearest similar road section for which measured data were available. In some cases, the speed limit of the road section was used as the average speed of traffic on the road if other data were not available. Unfortunately, due to the rural nature of the area, recent traffic count data is only available for a few locations, mainly on the main trunk road (A595) and some roads in Whitehaven. Therefore, the traffic speed and flow data used in Airviro are as described in the Stage 3 assessment dispersion model studies (Hill and Simpson, 2000) with the exception of the main trunk roads and some urban roads in Whitehaven which have been updated from the GB National Road Traffic Survey (Table C1).

Table C1: Annual Average Daily Traffic Flows on main roads in Copeland[18]

Road	Street	Road Category	OS Easting	OS Northing	AADT	% HGV
A5093	West of Millom	A Class Principal road in Rural area	315000	480300	2033	3
A595	Between Silecroft and the Green (Millom)	A Class Principal road in Rural area	315000	484500	1686	9
A595	Holmrook-Greengarth	A Class Principal road in Rural area	307960	500000	4833	5
A595	Iron Bridge	A Class Trunk road in Rural area	301700	507950	14768	2
A595	S of St Bees turnoff	A Class Trunk road in Rural area	299720	514000	15354	3
A595	Egremont Road	A Class Trunk road in Urban area	298580	516000	16990	4
A595	Hensingham bypass	A Class Trunk road in Urban area	298419	516585	20223	3
A595	Between Hensingham bypass and Inkerman Terrace	A Class Trunk road in Urban area	298350	517100	33119	4
A5094	Back Corkickle	A Class Principal road in Urban area	298016	517425	16747	1
A595	Loop Road South (Whitehaven centre bypass)	A Class Trunk road in Urban area	298000	518000	14513	4
A5094	Lowther Street	A Class Principal road in Urban area	297370	518130	6628	1
A5094	Duke Street	A Class Principal road in Urban area	297530	518200	14093	3
A5094	New Road	A Class Principal road in Urban area	297900	519000	9984	2
A5086	North of Lamplugh	A Class Principal road in Rural area	307630	520000	4501	4

[18] GB National Road Traffic Survey, DfT for 2006 from http://www.dft.gov.uk/matrix/forms/results.aspx.

Road	Street	Road Category	OS Easting	OS Northing	AADT	% HGV
A595	Whitehaven north of Pelican garage	A Class Trunk road in Urban area	297900	520000	18904	5
A595	Whitehaven north of Howgate	A Class Trunk road in Rural area	299790	522000	18289	5
A597	Main Road	A Class Principal road in Rural area	301000	524400	10382	6
A595	Distington south of Lillyhall	A Class Trunk road in Rural area	301550	524700	16827	5
A596	Distington - Lillyhall	A Class Principal road in Rural area	301600	525000	6809	3
A597	Main Road	A Class Principal road in Urban area	299993	525455	8290	2
A596	High Street	A Class Principal road in Urban area	300750	528300	19482	5
A66	Gt Clifton bypass	A Class Trunk road in Rural area	303220	528510	8408	6
A66	Stainburn Road	A Class Trunk road in Urban area	301000	528610	14876	4
A595	A66 jn	A Class Principal road in Rural area	305000	528700	7972	9
A596	Hall Brow	A Class Principal road in Urban area	300782	529000	15762	5
A66	West of Sheep&wool centre, Cockermouth	A Class Trunk road in Rural area	311000	530150	10625	10

1.2 Time, fleet and road type variations

Data concerning the diurnal variation in traffic flows on roads in the Copeland area are 24-hour counts provided by WSP Development and Transportation Ltd and CAPITAdbs Ltd. Annual average diurnal variations in traffic flow were calculated for the following road types in the EDB (see Table C2):

- A Road,
- 9% HGV
- Urban.

Table C2: Diurnal variation in traffic flow.

Road type	A Road and 9% HGV*	Urban **
12:00 AM	1	0
1:00 AM	1	1
2:00 AM	0	1
3:00 AM	1	1
4:00 AM	2	2
5:00 AM	5	2
6:00 AM	11	2
7:00 AM	20	4
8:00 AM	21	10
9:00 AM	18	8
10:00 AM	19	7
11:00 AM	20	9
12:00 PM	21	7
1:00 PM	21	7
2:00 PM	21	9

Road type	A Road and 9% HGV*	Urban **
3:00 PM	22	9
4:00 PM	24	12
5:00 PM	26	12
6:00 PM	22	8
7:00 PM	15	2
8:00 PM	10	2
9:00 PM	7	2
10:00 PM	6	2
11:00 PM	4	2

* A Road and 9 % HGV: From average of A595 at Harecroft Hall and Distington for 2005, courtesy of WSP Development and Transportation Ltd.
* Urban Road: From Inkerman Terrace, Whitehaven for 2002, courtesy of CAPITAdbs Ltd.

Each road type was assigned a fleet composition, based on measured data. The fleet composition breakdown is shown in Table C3.

Table C3: National average fleet composition for all road types.

Vehicle type	A roads and Urban	9 % HGV
HDV	4	9
LDV	96	91
Total	100%	

Vehicle emission rates for 2006 were obtained from the Emission Factor Toolkit ver. 3a for Light duty vehicles (LDV) and Heavy duty vehicles (HDV).

2. Point Sources

Emission rates and static data (e.g. stack height) were not available for all the point sources identified as being potentially significant to the air quality in Copeland, therefore some assumptions had to be made. Static data were as presented in the Stage 3 assessment dispersion model studies (Hill and Simpson, 2000) and fugitive emissions are assumed to have a stack height of 5 m for use in dispersion modelling. The Environment Agency website provided annual emission rates for Part A authorised industrial processes during 2006, which are presented in Table C4. Where release rates are listed as a limit value (e.g. <100,000 kg y^{-1}), emission rates are assumed to be zero. Any underestimation of emission rate this may cause is accounted for by grid source emissions (section 3). Emission rates for Part B processes were not included explicitly but were accounted for by grid source emissions (section 3).

3. Grid sources

Background emissions of NO_x for each of the UNECE sectors recorded on a 1 x 1 km grid resolution were obtained from the UK National Atmospheric Emissions Inventory.

Grid sources based on data from the NAEI were split into the following UNECE sectors:

- Energy Production and Transformation
- Commercial, Institutional and Residential Combustion

- Industrial Combustion
- Industrial Processes
- Production and Distribution of Fossil Fuels
- Solvent Use
- Road Transport
- Other Transport
- Waste Treatment and Disposal
- Agriculture
- Nature
- Point sources

The different sources were kept separate so that they could be assessed individually if required, with the exception of industrial processes and point sources which were combined into one industrial source. It must be noted that double-counting of certain sources, particularly road sources, may occur if road sources themselves and the UK NAEI-derived road traffic grid sources are assessed at the same time. To avoid this, the NAEI gridded emission data were compared with the road and point sources that were explicitly detailed in the emissions database. The NAEI gridded data were then edited to remove grid cells where areas of overlap were identified.

Table C4: Emission rates from Part A processes in Copeland and the surrounding area during 2006[19]

Name	OS East	OS West	Process	Licence	SO_2	Unit	PM_{10}	Unit	CO	Unit	NOx	Unit	Dust, (TSP)	Unit	VOC	Unit
A. Alco Waste ALC006, BU8100IG	302500	524500	Other waste disposal	ALC006, BU8100IG	0	ton/y	0	ton/y	-	-	0	ton/y	-	-	-	-
A. BNFL AS5601	302706	503700	Non-ferrous metals	AS5601	0	ton/y	2.2	ton/y	-	-	0	ton/y	-	-	-	-
A. BNFL THORP AS5598	302703	503701	Non-ferrous metals	AS5598			0	ton/y	-	-	0	ton/y	-	-	-	-
A. Corus UK BK0841IQ	299800	527300	Ferrous metals	BK0841IQ	0	ton/y	0	ton/y	-	-	293	ton/y	-	-	-	-
A. Cumbria Waste Man bv8725IT	302500	524300	Waste landfilling	BV8725IT	0	ton/y	0	ton/y	-	-	0	ton/y	-	-	-	-
A. E on CHP UK Ltd BJ7638IZ	299609	530194	Combustion	BJ7638IZ	6.1	ton/y	0	ton/y	-	-	117	ton/y	-	-	-	-
A. Eastman Chemical (formerly Voridian) PP37315	300701	531701	Combustion	PP37315	0	ton/y	0	ton/y	-	-	0	ton/y	-	-	-	-
A. Fellside CHP AF7045	303600	503600	Combustion	AF7045	0	ton/y	0	ton/y	-	-	611	ton/y	-	-	-	-
A. Goldschmidt UK BM4198IC	301900	533300	Organic chemicals	BM4198IC	0	ton/y			-	-			-	-	-	-
A. Huntsman BM4180IR	296700	516103	Organic chemicals	BM4180IR	0	ton/y	0	ton/y	-	-	0	ton/y	-	-	-	-
A. Iggesund BJ7590IB	300400	531301	Paper, pulp and board	BJ7590IB	0	ton/y			-	-	0	ton/y	-	-	-	-
A. NPOWER Cogen Ltd BU3680ID	296701	516100	Organic chemicals	BU3680ID	0	g/s	0	g/s	0	g/s			-	-	-	-
A. Pechiney Aviatube BK0795IH	301910	524860	Non ferrous metals	BK0795IH	0	ton/y			0	ton/y	0	ton/y	-	-	-	-
A. Pentagon Chem BK9016IQ	299751	529751	Organic chemicals	BK9016IQ	-	-	-	-	0	ton/y			-	-	-	-
A. Summerleaze Regeneration Ltd GP3632PY	301965	527692	Waste Landfilling	GP3632PY	0	ton/y	-	-	0	ton/y	0	ton/y	-	-	-	-
A. Waste Recycling GP3037SJ	302600	524700	A. Waste Recycling GP3037SJ	GP3037SJ	0	ton/y	0	ton/y	-	-	0	ton/y	-	-	-	-

[19] Taken from www.environment-agency.gov.uk.

Table C5 Part B processes operating in Copeland during 2006

Name	OS East	OS West	Process	Licence
Part B AEA Technology	303468	503131	Use of bulk cement	CBC/95/008
Part B Bardon Aggregates	305500	517000	Use of bulk cement and quarry process	CBC/95/010
Part B Bardon Roadstone	310607	494068	Quarry process	CBC/95/011
Part B BNFL	302487	503982	Use of bulk cement	CBC/95/009
Part B BNFL	303001	504001	B16 Pile chimney concrete crushing	CBC/LAPC/022
Part B BNFL Drigg	305136	500050	Use of bulk cement. Blending, packing, loading	CBC/93/001
Part B Corkickle Service Station	297780	517630	Unloading of petrol into storage	CBC/LAPC/025
Part B Distington Crematorium Copeland BC	301000	523700	Crematorium	CBC/95/013
Part B E Moorhouse and Sons	299800	513000	Use of bulk cement	CBC/95/07
Part B Egremont Mining Co. Ltd.	301800	510300	Crushing and screening of haematite	CBC/96/018
Part B Ellis Davis	300029	513045	Unloading and storage of fuel	CBC/LAPC/028
Part B G&AM Lawson	300962	525145	Mobile crushing of concrete, bricks	CBC/96/014
Part B Hanson Quarry, Bigrigg	299500	512250	Quarry process	CBC/95/005
Part B Holmrook Service Station	308230	499325	Unloading of petrol into storage	CBC/95/24
Part B Morrison Stores Ltd	297600	517800	Unloading of petrol into storage	CBC/LAPC/027
Part B Pondfield Garage	296730	517250	Waste oil burner	CBC/95/030
Part B Roxylight Agricultural Land (Cumbria)	303800	522000	Coal, sizing, loading and unloading	CBC/LAPC/023
Part B Tesco Stores Ltd. Filling station	297300	518500	Unloading of petrol into storage	CBC/LAPC/026
Part B Transco, Sellafield	303000	504000	Odorising natural gas	CBC/LAPC/021
Part B UKAEA	304432	502972	Use of Bulk cement	CBC/LAPC/029
Part B Walkmill Service Station	299700	519600	Waste oil burner	CBC/95/001