Durham County Council: Detailed Assessment of Air Quality 2011 – Claypath

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Durham County Council: Detailed Assessment of Air Quality 2011

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1 Introduction

AECOM were commissioned by Durham County Council unitary authority to undertake a Detailed Assessment of Air Quality for the City of Durham for several areas, outside the existing Air Quality Management Area (AQMA), where the 2011 Air Quality Progress Report (DCC, 2011) identified potential exceedences of the annual mean air quality objective for nitrogen dioxide (NO_2).

The Council has declared an AQMA for NO_2 in parts of the city on the basis of previous detailed dispersion modelling and recent air quality monitoring. This report is intended to satisfy the council's Local Air Quality Management (LAQM) responsibilities by reviewing the extent of the Air Quality Management Area (AQMA) and to provide information to support the future local air quality strategy and action plans.

The Detailed Assessment was undertaken to assess the following area, which is outside the existing AQMA, and where there is concern regarding high concentrations of NO2. This assessment was undertaken to determine whether it is necessary or appropriate to extend the AQMA to include this area:

- Claypath.

Separate Detailed Assessments have been undertaken for the following areas, which will be reported separately from this report:

- New Elvet, Church Street and Hallgarth area, which is to the south of Claypath.
- Crossgate and Nevilles Cross, to the west of the City Centre, where monitoring has recorded exceedences of the annual mean NO_2 objective. This is a complex area of street canyons where relatively high concentrations of NO_2 have been recorded in close proximity to very low concentrations. Therefore, in accordance with the 2011 Progress report, additional monitoring is currently being undertaken, which will be used for verification purposes within a Detailed Assessment.

1.1 Report Structure

- Section 2 provides an overview of air quality guidance and legislation;
- Section 3 presents the current air quality in the City of Durham based on recent monitoring data and previous LAQM reports;
- Section 4 explains the methodology which was followed in this assessment;
- Section 5 presents the results of the Detailed Assessment; and
- Section 6 concludes the assessment.

2 Guidance and Legislation

2.1 Relevant Guidance and Policies

Overview of Relevant Air Quality Legislation and Policy

The provisions of Part IV of the Environment Act 1995 establish a national framework for air quality management, which requires all local authorities in England, Northern Ireland, Scotland and Wales to conduct local air quality reviews. Section 82(1) of the Act requires these reviews to include an assessment of the current air quality in the area and the predicted air quality in future years.

The UK Air Quality Strategy

Should the reviews indicate that the objectives prescribed in the Air Quality Strategy will not be met at relevant locations; the local authority is required to designate an Air Quality Management Area (AQMA). Action must then be taken at a local level to ensure that air quality in the area improves.

The Air Quality Strategy identifies several ambient air pollutants that have the potential to cause harm to human health. These pollutants are associated with local air quality issues, with the exception of ozone, which is recognised as being a regional problem.

The standards and objectives apply at locations where the public may be exposed; relevant exposure is defined by EPUK (EPUK, 2010):

> *"Guidance from the UK Government and Devolved Administrations makes clear that exceedences of the health based objectives should be assessed at outdoor locations where members of the public are regularly present over the averaging time of the objective*."

Local Air Quality Management Review and Assessment

It is the responsibility of the Local Authority to undertake Review and Assessment work in accordance with the regime defined in the technical Guidance LAQM.TG(09). The purpose of the regime is to update and publish information regarding local air quality monitoring, and to identify possible areas of exceedence through screening and modelling.

Part of the regime is to undertake Detailed Assessment of possible areas of exceedence, which may be subsequently declared as an AQMA. The purpose of the Detailed Assessment is to identify with reasonable certainty whether or not a likely exceedence of the national objective (an annual mean concentration of 40 microgrammes/m^3 for Nitrogen Dioxide) will occur within the possible area of exceedence. To fulfil this requirement the Detailed Assessment is required to determine the magnitude and geographical extent of the exceedence.

2.2 Nitrogen Dioxide

The Government and the Devolved Administrations adopted two Air Quality Objectives for NO_2 to be achieved by the end of 2005. In 2010, mandatory EU air quality limit values for NO_2 should apply in the UK (although the UK government is applying for derogation until 2015). The EU limit values for NO_2 are the same as the national objectives for 2005 (HMSO, 2010):

- An annual mean concentration of 40 µg/m^3; and
- An hourly mean concentration of 200 µg/m^3, to be exceeded no more than 18 times per year.

The number of exceedences of the hourly objective show considerable year-to-year variation, and is driven by meteorological conditions, which give rise to winter episodes of poor dispersion and summer oxidant episodes.

NO_2 and nitric oxide (NO) are both oxides of nitrogen, and are collectively referred to as NO_X. All combustion processes produce NO_X emissions, largely in the form of NO, which is then converted to NO_2, mainly as a result of its reaction with ozone in the atmosphere. Therefore the ratio of NO_2 to NO is primarily dependent on the concentration of ozone and the distance from the emission source.

In recent years a trend has been noted whereby NO_2 concentrations have not been falling, or have been increasing, at certain roadside monitoring sites, despite emissions of NO_X falling. The 'direct NO_2' phenomenon is having an increasingly marked effect at many urban locations around the country and must be considered when undertaking modelling studies and in the context of future local air quality strategy. At the end of September 2010 Defra released a brief FAQ (Frequently Asked Question) note on the issue (Defra, 2010), acknowledging that NO_2 concentrations have not fallen as projected over the past 6-8 years.

The note acknowledged that the reasons for the disparity were not fully understood, and hence stated that updated LAQM guidance will not be released until the reasons are fully understood. Subsequently, Defra published a draft report in March 2011 (Defra, 2011c), which discusses possible reasons for the disparity between modelling and monitoring in detail, such as degradation of exhaust catalysts in early Euro-compliant vehicles, understanding of fleet profiles, the relationship between speed and emissions, and the different emissions contribution from petrol and diesel vehicles . This is discussed further in Section 4.3, in regard to how it has been considered in the modelling assessment.

3 Baseline

3.1 Local Air Quality Management

Durham County Council (DCC) is a 'unitary' Council, established on 1st April 2009 when the seven former District and Borough Councils within the County merged with the previous Durham County Council. This authority is now responsible for Review and Assessment duties for the county administrative area, including the City of Durham.

With regard to the City of Durham, the declaration of an AQMA was recommended in 2008, however due to the Council reorganisation, it was not declared until May 2011. The extent of the AQMA is provided in Appendix A, Figure 4 and is composed of a single area including Milburngate, Framwellgate Peth, Milburngate Bridge, Leazes Road and Gilesgate.

The 2011 Progress Report reviewed monitoring data from the local NO_2 diffusion tube network, which was significantly extended in 2011. This report identified exceedences of the annual mean NO_2 objective at areas outside the AQMA and concluded that it would be necessary to undertake the following Detailed Assessments:

- Claypath, in the city centre
- New Elvet, Church Street and Hallgarth, south of the city centre
- Crossgate lights, Nevilles Cross, The Peth and Colpitts Terrace, to the west of the city centre.

This report considers Claypath, where monitoring has recorded concentrations of NO_2 very close to the 40 $\mu g/m^3$ annual mean objective at residential properties outside the AQMA. The report was specifically undertaken to identify areas of likely exceedence that should be included within the AQMA.

3.2 Monitoring

The Council currently undertake monitoring for NO_2 using passive diffusion tubes. Figures 5 and 6 in Appendix B provide the monitoring locations of the current diffusion tube network.

The following sites exceeded the annual mean objective in 2010:

- D8 (formerly D13) Highgate north, located within the extent of the AQMA;
- D20(formerly D14) Gilesgate, located within the extent of the AQMA;
- D12 (formerly D15) Colpitts Terrace, located outside of the AQMA;
- D1 (formerly D20) Dragon Lane, located within the extent of the AQMA;
- D11 Crossgate Lights. This is a new site installed outside the AQMA in 2010, near Colpitts Terrace;
- D14 The Gates, located within the extent of the AQMA;
- D43 The Peth. This is a new site installed outside the AQMA in 2010, on Crossgate Peth near Colpitts Terrace;
- D19 Hallgarth St west. This is a new site installed outside the AQMA in 2010, at the junction of New Elvet and Church Street. This site is located on a traffic island is therefore not representative of relevant exposure.

The diffusion tube network was reviewed and extended in 2010 and again at the start of 2011.

A continuous NO_2 analyser was installed at a roadside location on Gilesgate in 2011 (see Table 2). This will be used in the future to determine a local diffusion tube bias adjustment factor, although as only a few months of data were available at the time of writing it was not used for the purposes of this study.

Previous monitoring in Durham City included two urban background sites; Byland Lodge and McNally Place; however, these were discontinued in 2007. A new monitoring location at an urban background site was installed at The Sands (D59) in 2011, although insufficient data was available to use it in this study.

Five of the diffusion tube monitoring sites are within, or near, the study area and were used for verification. The data for these sites are provided in Table 1.

Table 1: Non-continuous Monitoring in the City of Durham

Former ID	Current ID	Location	Type	OS Grid Reference		Annual Mean NO_2, µg/m^3			
				X	Y	2007	2008	2009	2010
D1b	D5	Millburngate [B]	Roadside	427357	542606	22.2	25.3	28.0	34.5
D14	D20	Gilesgate	Roadside	428305	542718	39.0	**41.8**	**47.6**	**45.4**
D18	D3	Claypath	Roadside	427983	542712	-	-	34.2	31.4
-	D4	39 Claypath	Kerbside	427630	542695	-	-	-	37.6
-	D42	Claypath	Roadside	427484	542623	-	-	-	38.9

Note: Exceedences of the UK air quality standard objective highlighted in bold. [A] Site D5, Millburngate, is located on a lamppost on a road parallel, and lower, than Millbungate Bridge. Therefore, this site is effectively level with the carriageway. .

Table 2: Continuous Monitoring in the City of Durham

ID	Location	Type	OS Grid Reference	
			X	Y
D60	Gilesgate (operational in April 2011)	Roadside	428535	542750

3.3 Estimated Background Concentrations

A large number of sources of air pollutants exist which individually may not be significant, but collectively, over a large area, need to be considered. The concentrations calculated by the model due to vehicle emissions can then be added to background concentrations to give the total concentration.

Monitored pollutant concentrations at locations away from the direct influence of roads or industrial sources ('background' locations) are discussed above in Section 3.2. However modelled estimates of background air quality concentrations are also provided on the Defra Air Quality website (Defra, 2011b) for each 1 km Ordnance Survey (OS) square in the UK. The estimated background concentrations for the OS grid squares containing the study area are provided in Tables 3, 4 and 5. These data were downloaded in January 2011.

As discussed in local air quality guidance, LAQM.TG(09) (Defra, 2009a), for the purpose of modelling, background contribution of modelled road sources must be discounted from the total background pollutant concentrations, to give 'adjusted' values. The adjusted NO_2 concentrations for each year were determined from the available NO_X data, using version 1.1 of the 'Background NO_2 Calculator' tool provided on the Defra website.

Table 3: Grid Locations for Estimated Background Pollutant Concentrations

Location	Major Roads Included in Grid	OS Grid Square Centre	
		X	Y
Durham Centre	Millburngate, Framwellgate Peth, New Elvet	427500	542500

Table 4: Estimated Annual Mean Background Pollutant Concentrations, Durham Centre

Pollutant	Total, µg/m^3	Adjusted, µg/m^3
NO_X	23.5	19.0
NO_2	16.4	13.6

The estimated background concentrations in Table 4 are well below the annual mean objective, although it is noted that the square centred over the centre of Durham indicates generally higher concentrations, which are due to a greater density of various emission sources.

The Council has not undertaken background monitoring in the city in 2009, the modelled year, and so it was necessary to use the estimated background pollutant concentrations given in Table 4. These values are broadly similar to those monitored at Byland Lodge and McNally Place in 2006, of 18.5 µg/m^3 and 20.3 µg/m^3 respectively.

4 Assessment Methodology

4.1 Assessment Procedure

The modelling and assessment was undertaken in accordance with the methodology defined in technical guidance LAQM.TG(09) (Defra, 2009b). The detailed modelling assessment considered the Claypath area, which is outside the existing AQMA, and which has recorded locations potentially exceeding the annual mean NO_2 objective.

4.2 AAQuIRE

The AAQuIRE dispersion modelling software, developed by AECOM (formerly Faber Maunsell Ltd), was used for the detailed assessment.

AAQuIRE currently uses the CALINE4 model for the dispersion of road-traffic emissions and AERMOD for all other sources. Both of these models are fully validated and have been extensively used worldwide. These are relatively complex models designed for detailed assessment of local areas, which are used within AAQuIRE for both local and larger scale studies.

Further details are provided in Appendix C.

4.3 Emissions Factors

As discussed in Section 2.2, in recent years it has been noted that NO_2 concentrations have typically not been falling, particularly at roadside monitoring sites, despite emissions of NO_X falling. At the end of September 2010 Defra released a brief FAQ note on the issue (Defra, 2010), acknowledging that NO_2 concentrations have not fallen as projected over the past 6-8 years. In March 2011 (Defra, 2011c) a detailed report was published discussing the reasons for the discrepancy in predictions, although this was published after much of the modelling work for this project had been completed.

Therefore, for the purposes of this modelling study, the vehicle emissions database that is interrogated by AAQuIRE has been altered so that NO_X emissions from diesel Euro 2-5 vehicles were equivalent to NO_X emissions from diesel Euro 1 vehicles. This reflects the current understanding that it is thought likely that vehicle emissions factors for diesel vehicles underestimate NO_X emissions in 'real-world' conditions. In particular, it is thought likely that diesel Euro 2, 3, 4 and 5 vehicles emit similar quantities of NO_X as Euro 1 engines. At the time of writing (March 2011) this was considered to be the most accurate and representative method of predicting current and future NO_X and NO_2 concentrations.

4.4 NO_X/NO_2 Ratios

The proportion of NO_2 in NO_X varies greatly with location and time according to a number of factors including the amount of oxidant available and the distance from the emission source. NO_X concentrations are expected to decline in future years due to falling emissions, therefore NO_2 concentrations will not be limited as much by ozone and consequently it is likely that the NO_2/NO_X ratio will increase in the future. However, Defra has recently acknowledged that NO_2 concentrations have not been dropping as expected, as discussed above in Section 2.2 and 4.3, and has advised local authorities to consider this when undertaking modelling studies and when planning for the future.

In this study modelled NO_X values were converted to NO_2 using the 'NO_X to NO_2' calculator version 2.1, released in January 2010, and available on the Defra local air quality management website (Defra, 2010b). The year and region for which the modelling has been undertaken are specified and local factors, such as an appropriate factor of NO_X emitted as NO_2, and the traffic mix set to all UK traffic, are used in the calculation.

4.5 Traffic Data

Traffic data was provided by the DCC Traffic Control group in the Regeneration & Economic Development department.

The data was collected by automatic units and recorded hourly total flows to enable Annual Average Daily Traffic (AADT) flow to be determined.

Speed data were recorded at several sites, but where it was not available assumptions were made based on national speed limits. The speed data were also adjusted to take account of slowing at junctions and roundabouts and where the gradient of the road increases (by reducing the speed, the effect of engines being under greater load is accounted for).

Claypath itself is a very narrow road with a steep section through the junction with Providence Row, which is controlled by traffic lights. Therefore, the speeds for this section were slowed substantially, to approximately 10-15 km/h to represent the very high engine loading applied to vehicles accelerating away from the junction. This was consistent with the methodology discussed in LAQM.TG(09), and the verification procedure specifically identified this issue at the diffusion tube at 39 Claypath (site D4).

Table 5: Traffic Flows Used in Model

Model Road ID	Recording Date	AADT [A]	HGV %	Speed (km/h) [B]
Milburngate Bridge EB	2010	24,717	3.8	46
Milburngate Bridge WB	2010	24,831	3.8	43
Gilesgate	2010	17,305	5.7	55
Leazes Road	2010	39,850	4.1	56
Claypath	2006	5,574	2.4	48

Note: [A] the daily flows are subject to the hourly flow profile in Figure 1. [B] Average speeds are subject to the profile in Figure 2, and slowing at junctions and on steep hills.

The data were also used to determine daily average speed and flow profiles (Figure 1 and 2), which were assigned to the modelled roads. These profiles account for congestion when peak traffic times results in greater numbers of vehicles and lower speeds:

- Figure 1 illustrates the daily flow profile, which was very similar at all of the roads for which these data were available. Flows increase substantially at 06:00 to a morning rush-hour peak at 08:00, then increase further through the day to an afternoon peak at 16:00 before tailing-off slowly during the evening. The profile applies a fraction of 1 to the modelled AADT for each hour of the day.
- Figure 2 illustrates the speed profile of roads for which hourly speed data were available. Typically, speeds reduce due to queuing around 8am and 4-6pm, which coincides with rush hour. The profile applies a factor to the speed for each hour of the day, where a factor greater than 1 increases the speed, and less than 1 decreases it.

Figure 1: Diurnal Vehicle Flow Profile for Modelled Roads

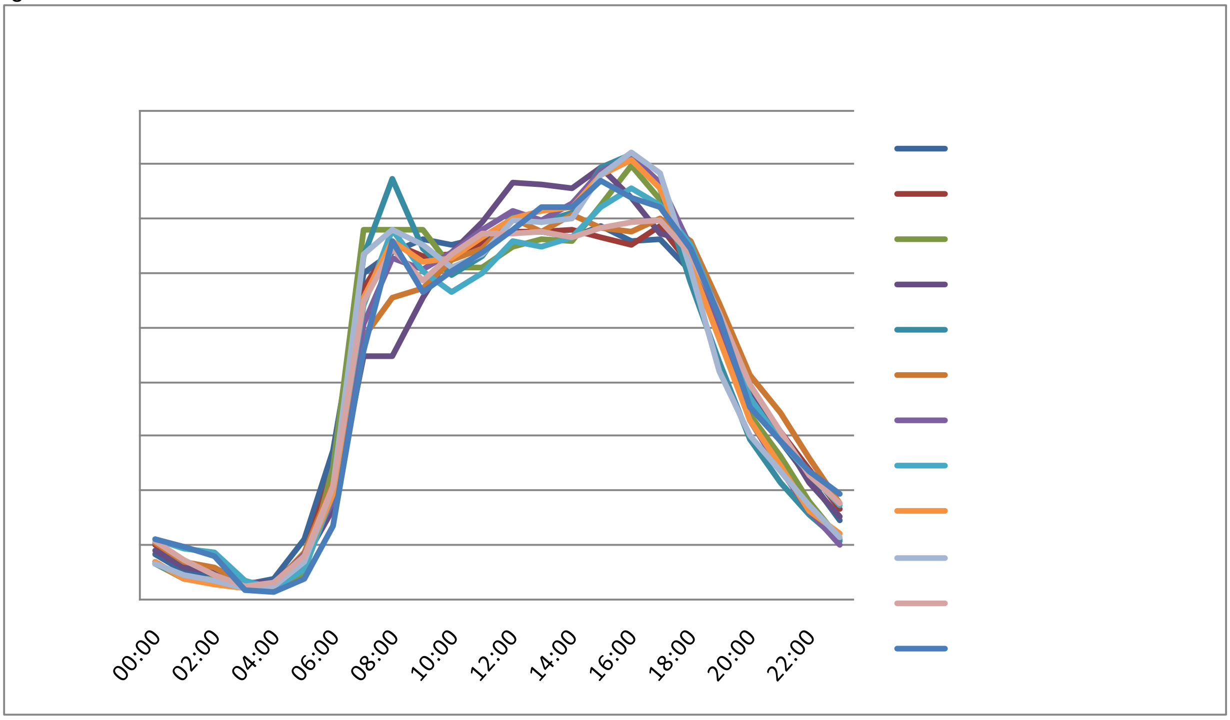
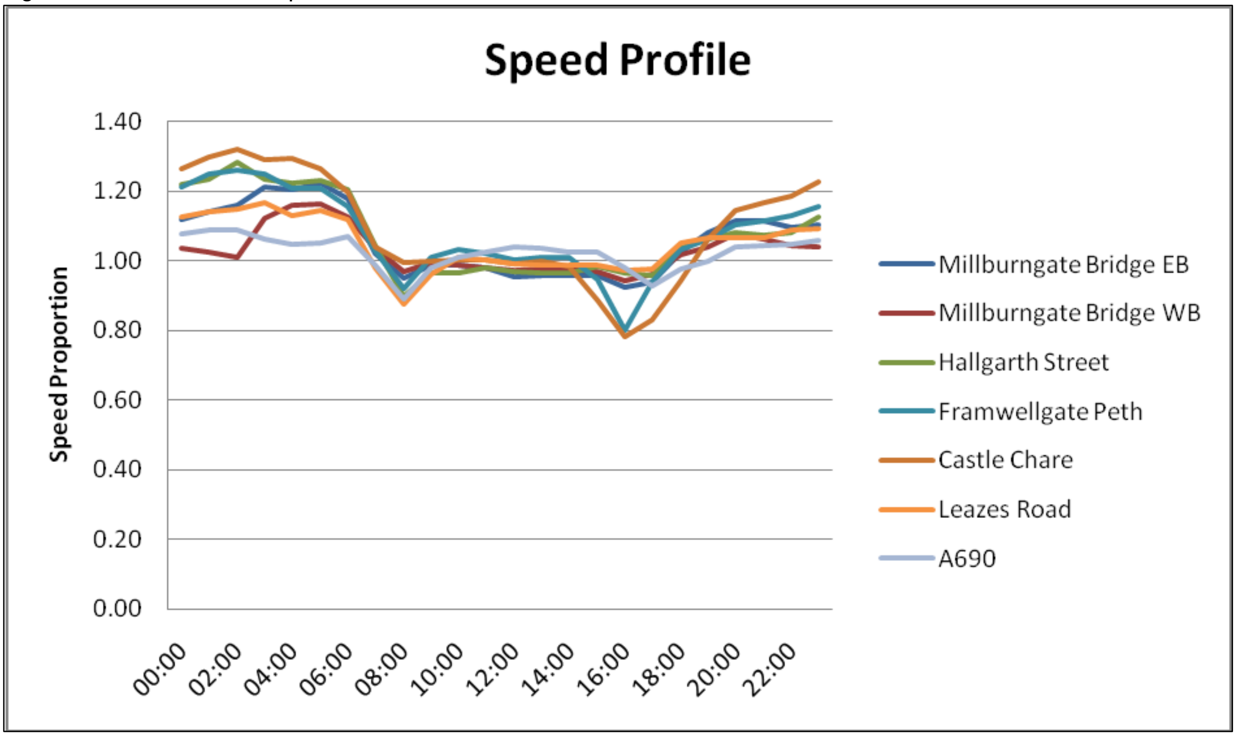


Figure 2: Diurnal Vehicle Speed Profile for Modelled Roads



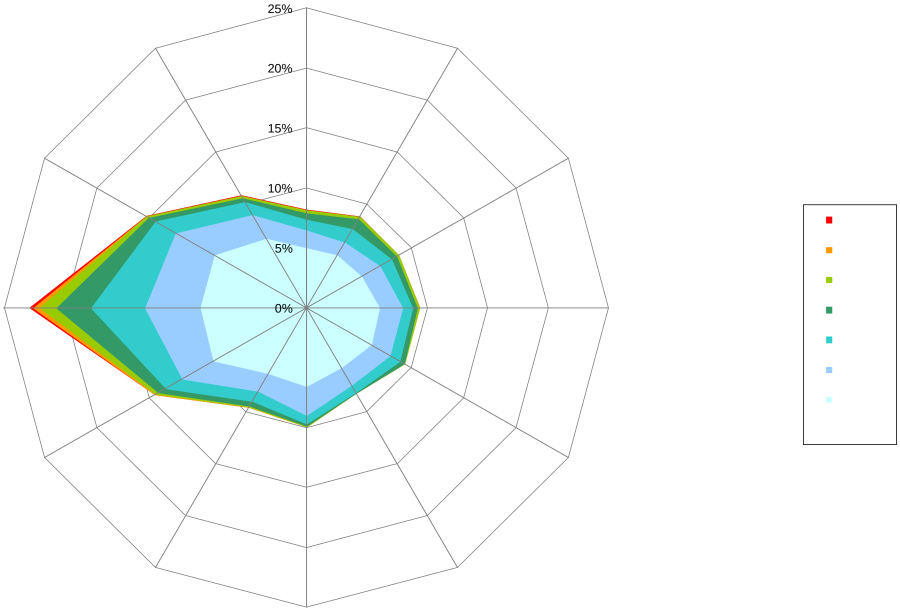
4.6 Meteorological Data

Meteorological data used in the model were obtained for Newcastle Airport for the base study year, 2010. This is the nearest recording station to Durham, located approximately 20 miles to the north, and is considered to be the most appropriate for the modelling assessment.

The windrose for 2010 is presented in Figure 3 and shows that the predominant wind direction is from the west. The 2010 conditions did not display the typical prevailing south-westerly component, although all directions occurred for periods throughout the year.

The 2010 meteorological conditions have been associated with atypically high concentrations of NO_2 reported by local authorities throughout the UK. Whilst this trend was not specifically identified in Durham City, an essential part of the model was the verification with local monitoring data recorded during the same year.

Figure 3: Wind Rose for Newcastle Airport, 2010



4.7 Sensitive Receptors

Specific locations were selected that were considered to be representative of relevant exposure, in accordance with the definition discussed in Section 2.1.2. The locations of the three selected sensitive receptors and the three DCC monitoring locations are presented in Table 6 and Appendix E, Figure 9.

The concentrations predicted at the diffusion tube monitoring locations were used for model verification, as discussed in Section 4.8 and Appendix D.

Table 6: Modelled Receptor Locations

Receptor		OS Grid Coordinate	
ID	Location	X	Y
D3	Claypath	427983	542712
D4	39 Claypath	427630	542695
D42	Claypath	427484	542623
C1	Claypath East	427849	542714
C2	Claypath Centre	427750	542722
C3	Claypath West	427476	542618

4.8 Model Error and Verification

When using modelling techniques to predict concentrations, it is necessary to make a comparison between the modelling results and the monitoring data, to ensure that the model is reproducing actual observations. Modelling results are subject to systematic and random error; systematic error arises due to many factors, such as uncertainty in the traffic data and the composition of the vehicle fleet, and uncertainty in the meteorological dataset. This can be addressed and, if necessary, adjusted for by comparison with monitoring data.

The model was adjusted using monitoring data from 2010. This methodology was consistent with LAQM.TG(09), whereby traffic data and meteorology from 2010 were compared directly with 2010 monitoring data. In accordance with the methodology discussed in LAQM.TG(09), an adjustment factor of 1.7 was applied to modelled NO_x concentrations in the study area.

Further details of the verification process are in Appendix D.

5 Detailed Assessment Model Results

Detailed dispersion modelling was undertaken using the AAQuIRE dispersion model. The model output has been verified by comparison with local monitoring results and adjusted accordingly, as detailed in Appendix D.

5.1 Modelled Areas

Predicted annual mean concentrations of NO_2 within the study area are presented in Appendix E, Figure 9. The plot indicates the areas where the annual mean concentrations are predicted to exceed the 40 $\mu g/m^3$ objective (indicated in yellow), plus one standard deviation (indicated in green and orange), or two standard deviations (indicated in blue and red).

The value for one standard deviation of 1.5 $\mu g/m^3$ was calculated in the verification procedure by comparison with the diffusion tube monitoring sites within the study area. A lower value indicates better confidence in the results, and it is considered that this value gives good confidence, with all of the predicted values within 10% of the monitored values.

The results of this assessment indicate that the annual mean objective is unlikely to be exceeded at any location of relevant exposure within Claypath. The highest concentrations, within one or two standard deviations, were predicted to occur at:

- North of the junction between Claypath and Providence Row, where Claypath is relatively steep and cars will be accelerating uphill away from the traffic light controlled junction; and
- The western end of Claypath near the bridge over Leazes Road leading to Saddler Street, partly due to emissions from vehicles using Millburngate, which passes underneath Claypath. Several properties in this area are predicted to be exposed to concentrations exceeding the annual mean objective, which is consistent with the data recorded at the D42 monitoring site.

Therefore, the model indicates that whilst there are elevated concentrations on Claypath, the areas where concentrations are close to, or exceeding, the annual mean objective are partly caused by proximity to Leazes Road, which is a major thoroughfare through the city and is already declared as part of the AQMA. This area has been blown-up within Figure 9, with the individual properties on Claypath exceeding the annual mean objective shaded in grey.

5.2 Predicted Concentrations

The locations of the specific receptors where annual mean concentrations were predicted are presented in Appendix E and in Table 7, below. All receptors represent sites of relevant exposure and are located on the facade of residential properties. These locations were modelled in addition to the monitoring locations as discussed in Section 4.7.

All of the predicted values are above 30 $\mu g/m^3$. The predicted concentration of NO_2 around monitoring point D4, which is away from the nearby major roads within the AQMA, is shown to exceed the objective but not at a location that is representative of relevant exposure. At receptor position C3, in close proximity to the monitoring location D42 situated at the western end of Claypath, the total concentration of NO_2 increases sufficiently to indicate that the objective is being exceeded at the residential properties above the following properties (also see Appendix E, Figure 10):

- BSM, 97 Claypath;
- Pagebet, 94 Claypath;
- St Cuthberts Hospice, 93 Claypath;
- Empty shop between BSM and Pagebet.

Table 7: Predicted 2010 Annual Mean Concentrations at Sensitive Receptors

Receptor ID	Location	OS Grid Co-ordinates		Modelled Annual Mean NO_2 Concentration ($\mu g/m^3$)
		X	Y	
D3	Claypath	427983	542712	34.1
D4	39 Claypath	427630	542695	38.6
D42	Claypath	427484	542623	39.5
C1	Claypath East	427849	542714	30.4
C2	Claypath Centre	427750	542722	33.1
C3	Claypath West	427476	542618	41.9

5.3 Summary

The model indicates that the concentration of NO_2 at modelled locations of relevant exposure is generally below the 40 $\mu g/m^3$ objective, but above 30 $\mu g/m^3$. However, this is sufficient for the annual mean to be exceeded at locations on Claypath near Leazes Road. Therefore, whilst traffic on Claypath itself is not considered to cause an exceedence directly, it does contribute to a specific area where it is exceeded.

6 Summary and Conclusions

6.1 Summary

The assessment can be summarised as follows:

- A detailed modelling assessment considered locations outside the existing AQMA where potential exceedences of the NO_2 annual mean objective were identified in the 2011 Air Quality Progress Report;
- The results of the model were used to identify the extent of exceedences of the annual mean objective for NO_2;
- The predicted concentration of NO_2 on Claypath is generally below the 40 $\mu g/m^3$ objective, but above 30 $\mu g/m^3$;
- Exceedences of the annual mean objectives were predicted at several properties near the western end of Claypath where it crosses Leazes Road;
- Therefore, whilst traffic on Claypath itself is not considered to cause an exceedence directly, it does contribute to an exceedence near the existing AQMA.

6.2 Recommendations

The model predicted that exceedences of the NO_2 annual mean objective were likely to occur at the western end of Claypath. This area of exceedence was partly due to the contribution from traffic using Claypath, but was predominantly due to proximity to Leazes Road, which is within the existing AQMA.

Therefore, it is recommended that the AQMA should be amended to specifically include the properties at the western end of Claypath. However, since local traffic on this road is not predicted to be the major cause of the exceedence, it is not appropriate to declare the whole of Claypath as an AQMA.

7 References

Air Quality Framework Directive (96/62/EC).

COMEAP (1998). *The Quantification of the Effects of Air Pollution on Health in the United Kingdom.*

Council Directive 1999/30/EC relating to limit values for sulphur dioxide, nitrogen dioxide and oxides of nitrogen, particulate matter and lead in ambient air.

Council Directive 2008/50/EC on Ambient Air Quality and Cleaner Air for Europe.

Defra (2007) The Air Quality Strategy for England, Scotland, Wales and Northern Ireland

Defra (2009a). *Local Air Quality Management Technical Guidance LAQM.TG(09)*

Defra (2009b). *Local Air Quality Management Policy Guidance LAQM.PG(09)*

Defra (2010a) *The Air Quality Standards Regulations 2010 Statutory Instrument 2010 No. 64*

Defra (2010b) Emission Factor Toolkit, Version 4.2

Defra (2011a). *http://laqm1.defra.gov.uk/review/tools/background-maps-info.php?year=2008*

Defra (2011b). *http://laqm1.defra.gov.uk/review/tools/monitoring/calculator.php*

Defra (2011c) *Trends in NOx and NO2 emissions and ambient measurements in the UK*City of Durham Council (2008) Detailed Assessment

Durham County Council (2009) Updating and Screening Assessment

Durham County Council (2010) Progress Report

Defra (2011a) http://laqm.defra.gov.uk/review-and-assessment/tools/background-maps.html data downloaded January 2011

Defra (2011b). *http://laqm1.defra.gov.uk/review/tools/monitoring/calculator.php*

Directive 2002/3/EC relating to ozone in ambient air.

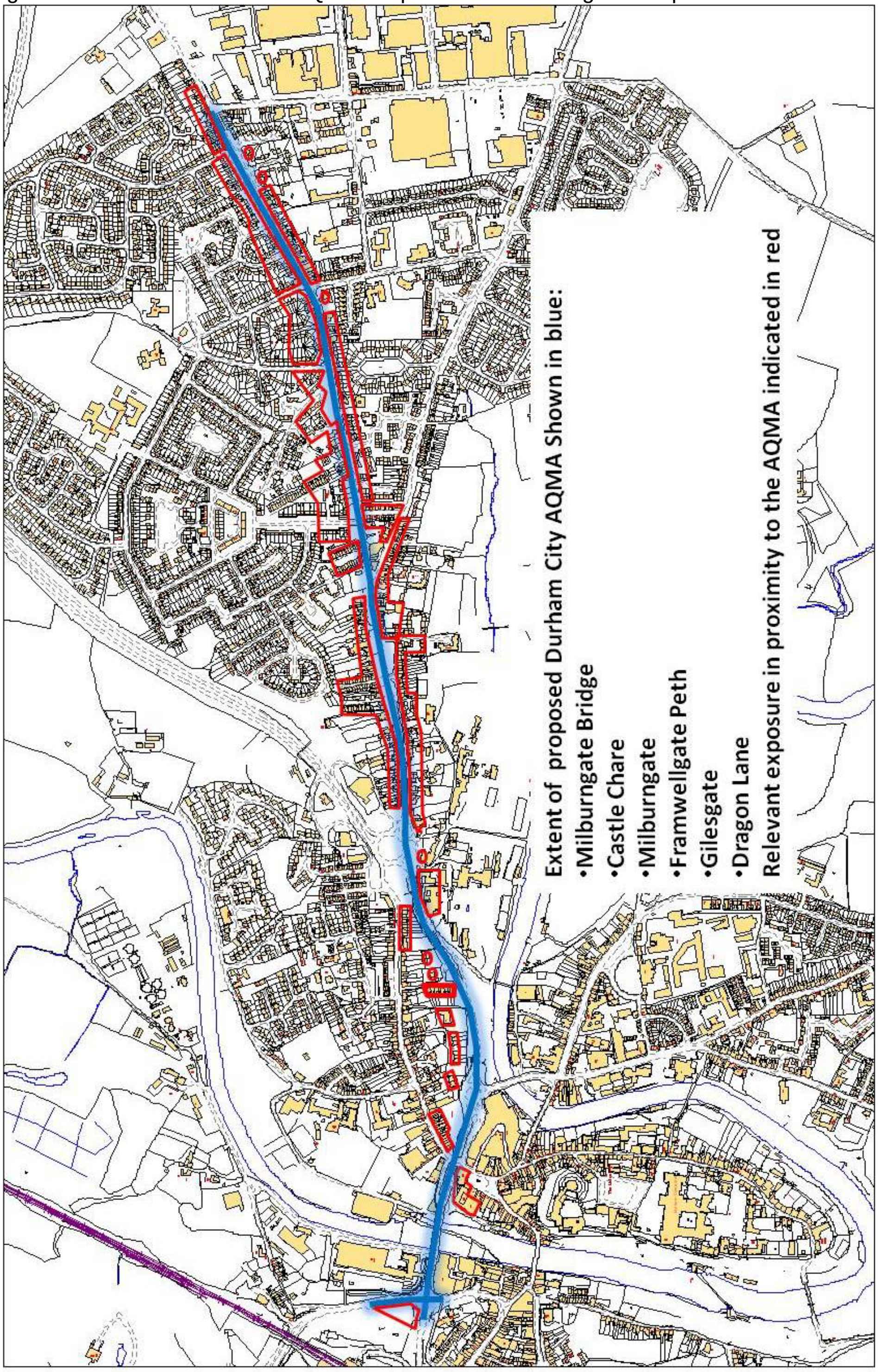
Directive 2008/50/EC of the European Parliament and of the Council of 21 May 2008 on ambient air quality and cleaner air for Europe.

Capabilities on project:
Environment

8 Appendices

Appendix A: AQMA Maps

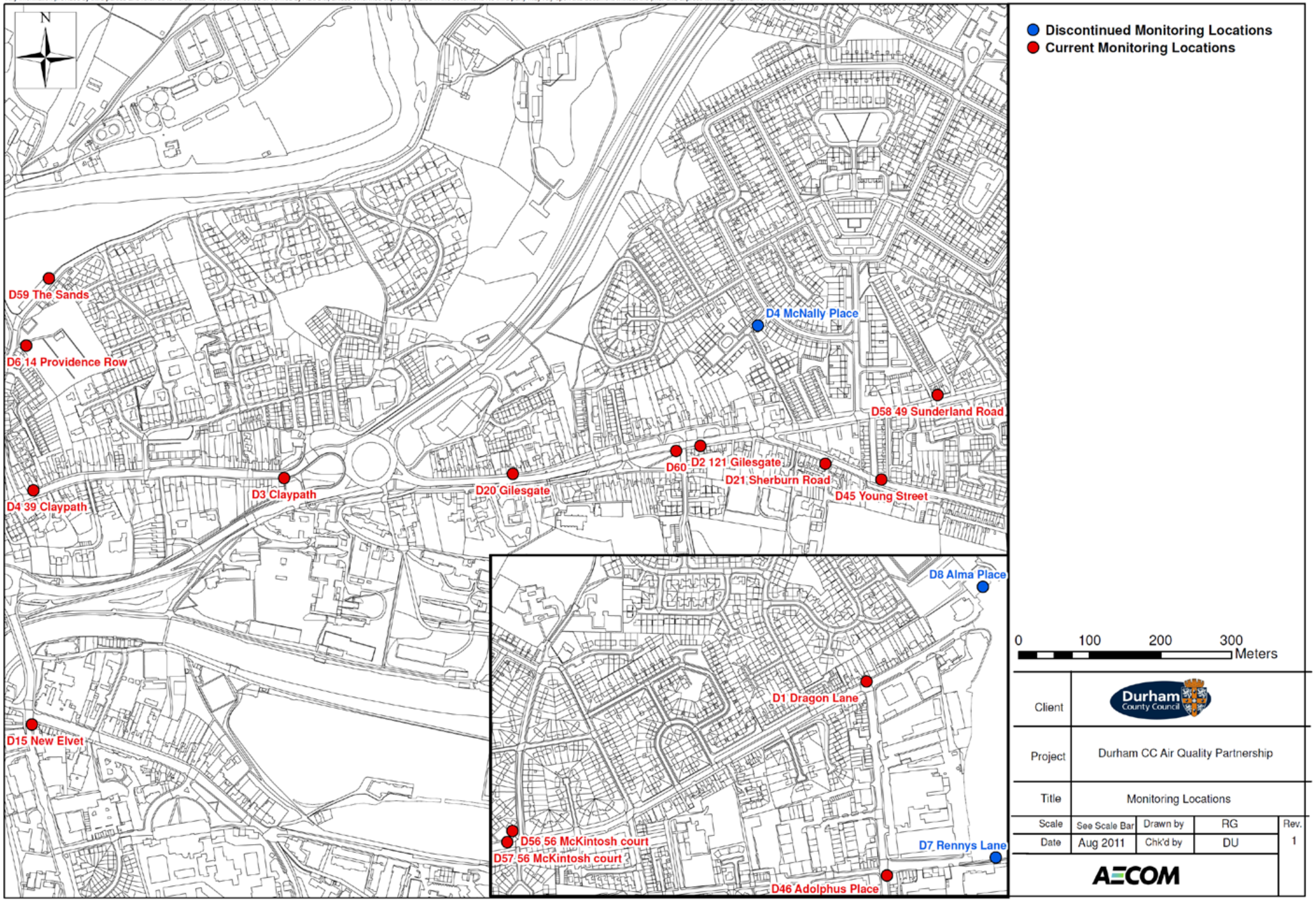
Figure 4: Provisional Extent of AQMA Proposed in 2010 Progress Report



Capabilities on project:
Environment

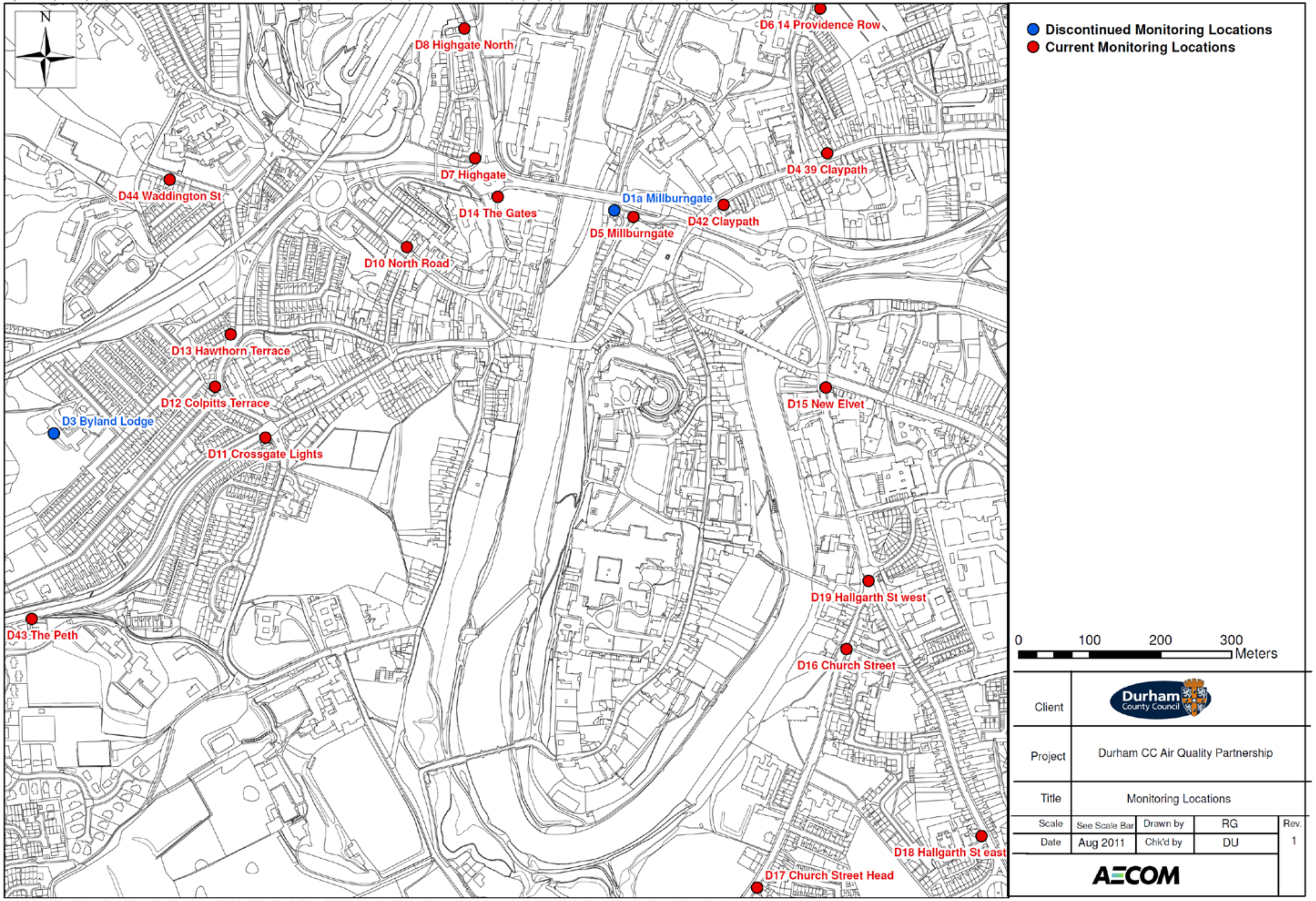
Appendix B: Monitoring Sites

Figure 5: Location of the Monitoring Sites in Durham City (East).



Capabilities on project:
Environment

Figure 6: Location of Monitoring Sites in Durham City (West)



Appendix C: AAQuIRE Software

The AAQuIRE 6.2 software is a system that predicts Ambient Air Quality in Regional Environments and comprises a regional air quality model and statistical package.

AAQuIRE was developed by Faber Maunsell Ltd (now AECOM) to meet three requirements in predictive air quality studies. The first requirement was an immediate need for a system that produced results that could be interpreted easily by non-air quality specialists to allow for proper informed inclusion of air quality issues in wider fora, the main example being to allow consideration of air quality issues in planning processes. This was achieved by allowing results to be generated over a sufficiently large study area, and at an appropriate resolution, for the issue being considered. The results are also presented in a relevant format, which is normally a statistic directly comparable with an air quality criterion or set of measured data being considered. AAQuIRE can also produce results directly comparable with all ambient air quality standards.

The second requirement was for a system to be based, initially, on existing and well-accepted and validated dispersion models. This has two advantages. The primary one is that it avoids the need to prove a new model against the accepted models and therefore enhances acceptability. The second advantage is that when appropriate new models are developed they can be included in AAQuIRE and be compared directly with the existing models, and sets of measured data, using the most appropriate statistics.

The final primary requirement for AAQuIRE was a consideration of quality assurance and control. An important aspect of modelling is proper record keeping ensuring repeatability of results. This is achieved within AAQuIRE by a set of log files, which record all aspects of a study and allow model runs to be easily repeated.

The ways in which AAQuIRE and the models currently available within it operate are discussed below.

The operation of AAQuIRE can be divided into five main stages. These are:

- the preparation of the input data;
- the generation of model input files;
- dispersion modelling;
- the statistical treatment of dispersion modelling results; and
- the presentation of results.

The first step in operating AAQuIRE is to prepare the input data. The following data are needed for the year and pollutant to be modelled:

- meteorological data expressed as occurrence frequencies for specified combinations of wind speed, direction, stability and boundary layer height;
- road system layout and associated traffic data within and immediately surrounding the study area;
- industrial stack locations and parameters; and
- a grid of model prediction locations (receptors).

The modelling is always carried out to give annual average results from which appropriate shorter period concentrations can be derived.

The second stage is the generation of the model input files required for the study. All the data collated in the first stage can be easily input into AAQuIRE, using the worksheets, drop down boxes and click boxes in the Data Manager section of the software. Data from spreadsheets can be easily pasted into worksheets, so that any complicated procedures required for data manipulation can be achieved before entry into AAQuIRE. Several diurnal and seasonal profiles can be defined for each separate source. The relevant meteorological data can also be specified at this stage.

The third stage is executing the models. The study area will usually be divided up into manageable grids and run separately using the Run Manager in AAQuIRE. The results from the separate files can be combined at a later stage. Pollutant concentrations are determined for each receptor point and each meteorological category and are subsequently combined.

The fourth stage is the statistical processing of the raw dispersion results to produce results in the relevant averaging period. Traffic sources and industrial sources can be combined at this stage provided the same receptor grid has been used for both. Background concentrations should also be incorporated at this stage.

The final stage is presentation of results. Currently the result files from the statistical interpretation are formatted to be used directly by the Surfer package produced by Golden Software Inc. Alternative formats are available to permit interfacing with other software packages. On previous projects the results have been imported into a GIS (e.g. ArcView and Map Info).

Appendix D: Model Verification

The model under-estimated concentrations when compared to the monitoring undertaken in 2010. Due to this discrepancy, the modelled results were adjusted in accordance with the procedure detailed in technical guidance LAQM.TG(09).

An adjustment factor was calculated as follows:

$NO_{X\ [monitored,\ traffic\ contribution]} = NO_{X\ [monitored]} - NO_{X\ [background]}$
$NO_{X\ [modelled,\ traffic\ contribution]} = NO_{X\ [modelled]} - NO_{X\ [background]}$

Adjustment Factor = $NO_{X\ [monitored,\ traffic\ contribution]}$ / $NO_{X\ [modelled,\ traffic\ contribution}$

The adjustment factor derived from this calculation was 1.82.

The adjustment factors were subsequently applied to the modelled NO_X concentrations, and background NO_X added to give the adjusted NO_X concentrations ($NO_{X\ [model\ adjusted]}$):

$NO_{X\ [model\ adjusted,\ traffic\ contribution]} = NO_{X\ [modelled,\ traffic\ contribution]}$ x Adjustment Factor
$NO_{X\ [model\ adjusted]} = NO_{X\ [model\ adjusted,\ traffic\ contribution]} + NO_{X\ [background]}$

The adjusted NO_X concentrations were then converted to NO_2 using version 2.1 of the 'NO_2 to NO_X' calculator provided by the Air Quality Archive and in accordance with the technical guidance, LAQM.TG(09).

Table 8: Comparison of Modelled and Monitored NO_2 Concentrations

Site Name	Monitor Type	Site Type	Modelled Height	Monitored Total NO_2	Modelled Total NO_2	% Difference [(mod-mon)/mon]
Claypath	Diffusion Tube	Roadside	1.5	31.4	25.9	-17%
39 Claypath	Diffusion Tube	Roadside	1.5	37.6	28.9	-23%
Milburngate	Diffusion Tube	Roadside	1.5	34.5	25.9	-25%
Gilesgate	Diffusion Tube	Roadside	1.5	45.4	32.5	-28%
Claypath	Diffusion Tube	Roadside	1.5	38.9	29.5	-24%

Figure 7: Total Modelled versus Monitored NO_2

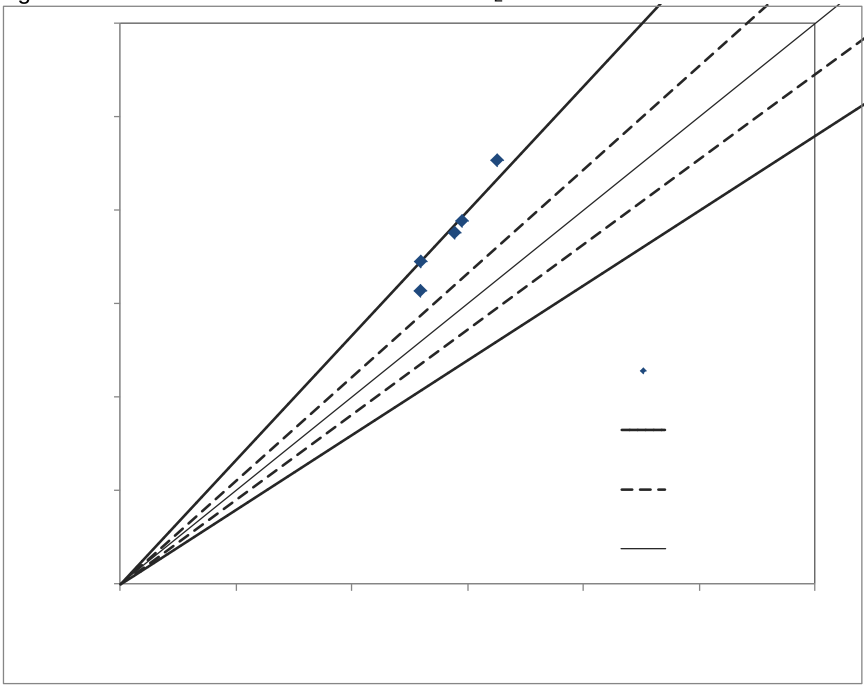


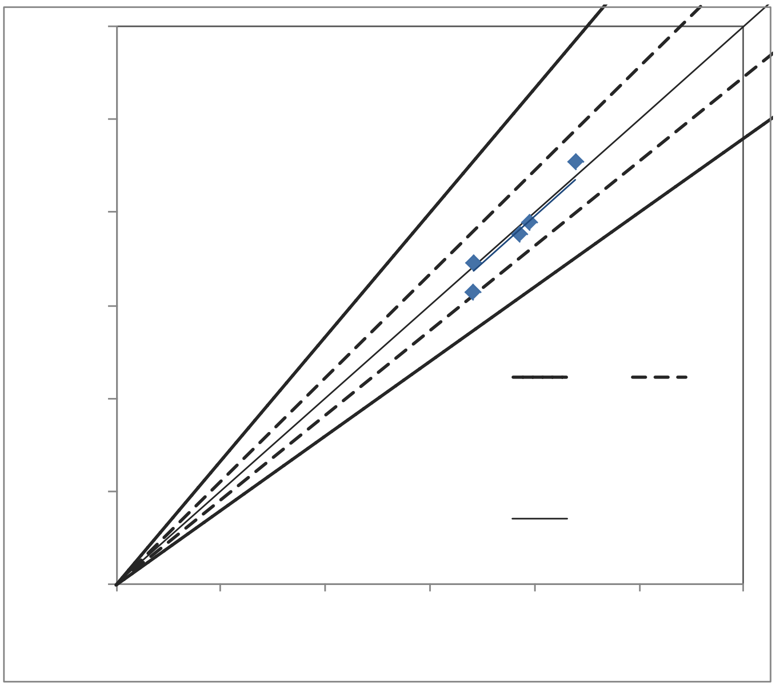
Table 9: Determination of Modelled and Monitored Rd NO_2 and Modelled Rd NO_X

Site Name	Monitored Total NO_2	Monitored Road NO_X	Adj Bknd NO_2	Monitored Road Contribution NO_2 (tot-bgd)	Monitored Road Contribution NO_X (tot-bgd)	Modelled Road Contribution NO_X (excl bgd)
Claypath	31.38	40.34	13.00	18.38	40.34	26.97
39 Claypath	37.59	56.58	13.00	24.59	56.58	33.80
Milburngate	34.52	48.34	13.00	21.52	48.34	27.06
Gilesgate	45.35	79.32	13.00	32.36	79.32	42.66
Claypath	38.86	60.10	13.00	25.86	60.10	35.31

Table 10: Determination of the Adjustment Factor and Total Adjusted NO_2

Site ID	Adjustment Factor for Modelled Road Contribution	Adjusted Modelled Road Contribution NO_X	Adjusted Modelled Total NO_X	Adjusted Modelled Total NO_2	Monitored Total NO_2	% Difference [(mod-mon)/mon]
Claypath		46.7	28.8	34.1	31.4	9%
39 Claypath		58.5	40.6	38.6	37.6	3%
Milburngate		46.9	29.0	34.2	34.5	-1%
Gilesgate		73.9	56.0	44.0	45.4	-3%
Claypath	1.7312	61.1	43.2	39.5	38.9	2%

Figure 8: Total Modelled and Monitored NO_2 (after adjustment of road NO_X)



Statistical Analysis

The data in Table 21 indicate the statistical confidence attributed to the model for the two areas.

The data show that the verification significantly improves the accuracy of the model, with a resultant RMSE of +/- 1.5 $\mu g/m^3$, with a similarly good correlation coefficient and fractional bias. The correlation coefficient and fractional bias are good, which indicates that the model is reasonably representative.

This range is shown in the plots (Appendix G) to define the extent of the areas of exceedence.

Table 11: Statistical Analysis of Model

	Ideal Value	Unverified	Verified
Correlation coefficient	1	0.97	0.97
RMSE	0	9.31	1.48
fractional bias	0	0.27	-0.01

Capabilities on project:
Environment

Appendix E: Model Outputs

Figure 9: Annual Mean NO_2 Concentration, 2010