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Local Air Quality Management: Detailed Assessment for *Castlereagh Borough Council*

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Local Air Quality Management:
Detailed Assessment for Castlereagh Borough Council

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Executive Summary

The Air Quality Strategy has established the framework for air quality management in the UK. Local authorities have a duty under the Environment Act 1995 and subsequent regulations to review and assess air quality in their areas on a periodic basis so as to identify all areas where the air quality objectives are being or are likely to be exceeded.

A phased approach has been adopted for the review and assessment process so that the level of assessment undertaken is commensurate with the risk of an exceedence of an air quality objective. An updating and screening assessment (USA) is required to be prepared every three years by all local authorities in the UK. If the USA indicates that there are areas where exceedences of air quality objectives are occurring, or likely to occur, the next step is to undertake a Detailed Assessment, the outcome of which may lead to the declaration of an Air Quality Management Area.

Castlereagh Borough lies to the southeast of Belfast in Northern Ireland. Its position in relation to Belfast, has made it a very popular area in which to live. Commuting times to the city centre from any part of the Borough are relatively short. This, combined with the major arterial routes passing through the Borough into Belfast, has made road transport the major air pollution concern. There are currently no air quality management areas in Castlereagh Borough.

Diffusion tube measurements at Normandy Court on the A20 Upper Newtownards Road in Dundonald had indicated exceedences of the annual mean objective for nitrogen dioxide in both 2007 and 2008. There is relevant exposure at this location. As a result, the Council initiated monitoring in the vicinity of Normandy Court in 2007, involving automatic measurements of nitrogen dioxide (and particulate matter). The annual mean concentrations derived were close to (in 2007) and below (in 2008) the annual mean objective. Castlereagh Borough Council commissioned the National Physical Laboratory to undertake detailed assessment involving dispersion modelling.

This report contains the detailed assessment. Modelling has been undertaken using the ADMS-Roads 2.3 dispersion model. NO_2 and PM_{10} concentrations have been modelled at specific receptors along the A20 Upper Newtownards Road, in the vicinity of Normandy Court in Dundonald, where exceedences have been monitored. The model results have been verified against the continuous monitor and NO_2 diffusion tube measurements in the assessment area.

Based on this detailed assessment and the review of the monitoring data within the areas under assessment, the following two recommendations are made to Castlereagh Borough Council:

1. To consider declaration of an Air Quality Management Area in the A20 Upper Newtownards Road, in the vicinity of Normandy Court in Dundonald, on the basis of NO_2, where exceedences of the annual mean objective are predicted at relevant receptor locations;
2. To continue monitoring NO_2 and PM_{10} at the current monitoring locations in order to ensure that any future changes in air quality are detected, notably locations representative of relevant exposure, i.e. at the façade of residential properties.

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Any questions or matters arising from this Report should be addressed in the first instance to Dr Garry Hayman at the National Physical Laboratory.

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1 Introduction

The Air Quality Strategy has established the framework for air quality management in the UK. Local authorities have a duty under the Environment Act 1995 and subsequent regulations to review and assess air quality in their areas on a periodic basis so as to identify all areas where the air quality objectives are being or are likely to be exceeded.

A phased approach has been adopted for the review and assessment process so that the level of assessment undertaken is commensurate with the risk of an exceedence of an air quality objective. An updating and screening assessment is required to be prepared every three years by all local authorities in the UK. If the USA indicates that there are areas where exceedences of air quality objectives are occurring, or likely to occur, the next step is to undertake a Detailed Assessment, the outcome of which may lead to the declaration of an Air Quality Management Area.

Diffusion tube measurements at Normandy Court on the A20 Upper Newtownards Road in Dundonald had indicated exceedences of the annual mean objective for nitrogen dioxide in both 2007 and 2008. There is relevant exposure at this location. As a result, the Council initiated monitoring in the vicinity of Normandy Court in 2007, involving automatic measurements of nitrogen dioxide (and particulate matter). The annual mean concentrations derived were close to (in 2007) and below (in 2008) the annual mean objective. Castlereagh Borough Council has now commissioned the National Physical Laboratory to undertake Detailed Assessment involving dispersion modelling.

This document is a report on the study undertaken for the Detailed Assessment and contains a summary of the results of the monitoring and modelling undertaken.

1.1 Description of Castlereagh Borough

Castlereagh Borough Council covers an administrative area of 84 km² to the southeast of Belfast in Northern Ireland (see Figure 1-1). The main centres are Newtownbreda, Carryduff, Dundonald and the villages of Moneyreagh and Crossnacreevy. The Northern Ireland Statistics and Research Agency gives the population for the borough as 65,633 (Mid 2006 Population Estimate).

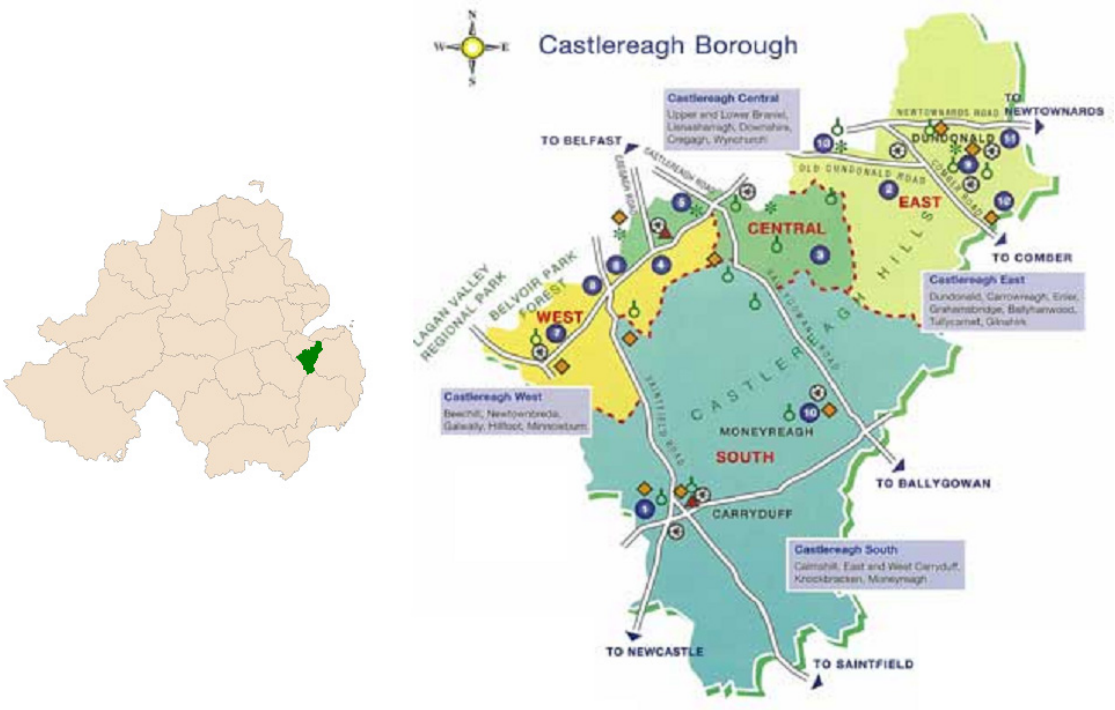


Figure 1-1: Location of Castlereagh Borough in Northern Ireland (left-hand map) and a detailed map of the Borough showing the major towns and administrative divisions (right-hand map).

Castlereagh Borough Council - Northern Ireland

The location of Castlereagh Borough in relation to Belfast has made it a very popular area in which to live. Commuting time to the city centre from any part of the Borough is relatively short. This, combined with the major arterial routes passing through the Borough into Belfast, has made road transport the major air pollution concern. There are currently no air quality management areas (AQMAs) in Castlereagh Borough.

The Borough of Castlereagh is surrounded by the neighbouring local authorities of Ards Borough Council, Belfast City Council, Down District Council, Lisburn Borough Council and North Down Borough Council. As part of a local government re-organisation planned for next year, Castlereagh Borough will be split and amalgamated into Belfast City and Lisburn City Councils.

1.2 Air Quality Legislation

1.2.1 Local Air Quality Management

The Air Quality Strategy (AQS) has established the framework for local air quality management (LAQM) in the UK. Local authorities have a duty under Part IV of the 1995 Environment Act and subsequent regulations to review and assess air quality in their areas on a periodic basis so as to identify all areas where the air quality objectives are being or are likely to be exceeded. This involves consideration of present and likely future air quality against the AQS objectives prescribed within the Air Quality Regulations.

Where the review and assessment process finds that pollutant concentrations will exceed AQS objectives by their target dates (in areas where the AQS objectives apply), the Local Authority are required to declare an Air Quality Management Area (AQMA) under Section 83(1) of the Environment Act 1995. The areas in which the AQS objectives apply are defined as locations outside buildings or other natural or man-made structures above or below ground where members of the public are regularly present and might reasonably be expected to be exposed to pollutant concentrations over the relevant averaging period of the AQS objective.

Guidelines for the 'Review and Assessment' of local air quality were first published in the 1997 National Air Quality Strategy (NAQS), along with associated policy guidance and technical guidance. For the First Round of Review and Assessment, local authorities undertook a 3-staged assessment process of increasing detail. Progression to the next stage was dependent on the outcome of the previous stage. In 2000, the Government reviewed the NAQS and published a revised AQS, to which an addendum was issued in February 2003. Revised LAQM Technical Guidance [LAQM.TG(03), TG (2003)] and Policy Guidance [LAQM.PG(03), PG (2003)] were issued in January 2003.

The 2003 guidance set the framework for the requirements of review and assessment for future years, taking account of experiences gained from the previous rounds. The framework for review and assessment begins with an Updating and Screening Assessment (USA) that considers the likelihood of all the AQS objectives being achieved across the Local Authority's administrative area. An updating and screening assessment is now required to be prepared every three years by all local authorities in the UK. If the USA indicates that there are areas where exceedences of air quality objectives are occurring, or likely to occur, the next step is to undertake a Detailed Assessment, the outcome of which may lead to the declaration of an Air Quality Management Area.

Having declared an AQMA the authority is required to confirm the findings of the Detailed Assessment work through further monitoring or modelling assessments. This Further Assessment should provide information on the source-apportionment of the pollutant emissions in order to identify the level of pollutant reduction required for the attainment of relevant air quality objectives. Additionally, consideration should be made to evaluating local management practices that could be used to improve air quality, and feed into the formulation of an Action Plan.

The Second Round of Review and Assessment (2003-2005) allowed local authorities to update the findings of their first round of review and assessment. Local authorities were asked to take into consideration changes in AQS Objectives and revised Technical Guidance (LAQM.TG(03)), new emission sources, and any significant proposed planning developments due to take place before the relevant AQS Objective target date.

Additional guidance was provided in the form of frequently asked questions (FAQs) and updated LAQM tools in January 2006 to assist with Third Round of Review and Assessment (2006-2008). This included revised modelled background concentration maps for NO_X, NO_2 and PM_{10}, updated future year calculation tools and updates on the assessment of specific sources (rail, shipping, poultry farms). In addition, in 2007, a new NO_X:NO_2 calculator was provided.

For the Fourth Round of Review and Assessment (2009-2011), now in progress, a number of changes were made to the format of the USA to ease the burden on local authorities. These changes were made following the lessons learned during the previous rounds, and in particular to the recommendations of the Evaluation Report that was commissioned in 2007 by the UK Government and the Devolved Administrations [Defra, 2007]. The most significant changes were for local authorities to assess air quality by *emission source* rather than on *a pollutant-by-pollutant basis* and to use web-based submission of the assessment. Revised policy and technical guidance were prepared.

At the time of writing, 233 local authorities across the UK have declared AQMAs. The vast majority of these AQMAs are associated with exceedences of AQS objectives for nitrogen dioxide (NO_2) or for nitrogen dioxide (NO_2) and particulate matter (PM_{10}), both related to road traffic emissions. Whilst other pollutants such as carbon monoxide (CO) and benzene are also associated with road traffic emissions, the latest national perspective on the occurrence of each of these pollutants suggests that these are no longer a problem at roadside locations across the UK.

1.2.2 Air Quality Objectives

The air quality objectives applicable to LAQM in Northern Ireland are set out in the Air Quality Regulations (Northern Ireland) 2003, Statutory Rules of Northern Ireland 2003, no. 342, and are shown in Table 1-1. This table shows the objectives in units of micrograms per cubic metre μg m^{-3} (milligrammes per cubic metre, mg m^{-3} for carbon monoxide) with the number of exceedences in each year that are permitted (where applicable).

Table 1-1: Air Quality Objectives included in Regulations for the purpose of Local Air Quality Management in Northern Ireland.

Pollutant	Air Quality Objective		Date to be achieved by
	Concentration	Measured as	
Benzene	16.25 $\mu g/m^3$	Running annual mean	31.12.2003
	3.25 $\mu g/m^3$	Running annual mean	31.12.2010
1,3-Butadiene	2.25 $\mu g/m^3$	Running annual mean	31.12.2003
Carbon monoxide	10.0 mg/m^3	Running 8-hour mean	31.12.2003
Lead	0.5 $\mu g/m^3$	Annual mean	31.12.2004
	0.25 $\mu g/m^3$	Annual mean	31.12.2008
Nitrogen dioxide	**200 $\mu g/m^3$ not to be exceeded more than 18 times a year**	**1-hour mean**	**31.12.2005**
	40 $\mu g/m^3$	**Annual mean**	**31.12.2005**
Particles (PM_{10}) (gravimetric)	50 $\mu g/m^3$, not to be exceeded more than 35 times a year	24-hour mean	31.12.2004
	40 $\mu g/m^3$	Annual mean	31.12.2004
Sulphur dioxide	350 $\mu g/m^3$, not to be exceeded more than 24 times a year	1-hour mean	31.12.2004
	125 $\mu g/m^3$, not to be exceeded more than 3 times a year	24-hour mean	31.12.2004
	266 $\mu g/m^3$, not to be exceeded more than 35 times a year	15-minute mean	31.12.2005

2 Air Quality Monitoring

In this section, information is provided on the air quality monitoring undertaken in Castlereagh Borough, together with a brief summary of the monitoring results for 2007 and 2008. Castlereagh Borough Council and the adjoining local authorities (Ards Borough Council, Down District Council, Lisburn City Council and North Down Borough Council) form the Eastern Group of Councils (EGC) for the purposes of air quality management and reporting. Fuller details on the 2007 and 2008 measurements can be found can be found in the 2008 progress report (EGC, 2008) and the 2009 updating and screening assessment (USA, 2009), respectively.

2.1 Site Locations and Instrumentation

During 2007 and 2008, Castlereagh Borough Council monitored ambient air quality at three sites using automatic instrumentation:

- Castlereagh Lough View Drive [for oxides of nitrogen (NO_x)[1] and particulate matter (as PM_{10}), 2002-present]
- Castlereagh Dundonald [NO_x and PM_{10}, 2007-present]
- Castlereagh Espie Way [sulphur dioxide (SO_2) and PM_{10}, 2002-2007]

Diffusion tube measurements of NO_2 were also made at a number of locations in the Borough. Information on the three automatic monitoring (A1-A3) and 6 diffusion tube (DT1-DT6) sites is provided in Table 1-1. The locations of these sites are shown in Figure 2-1. Figure 2-2 shows a more detailed map of the Dundonald area.

Table 2-1: Details of the Monitoring Sites

Site		Site Type	OS (NI) Grid Ref	Pollutants Monitored	In AQMA?
A1	Castlereagh Lough View Drive	Roadside	E 335749 N 370711	NO-NO_2-NO_x, NO_2 (DT), PM_{10}	N
A2	Castlereagh Dundonald	Roadside	E 342016 N 374041	NO-NO_2-NO_x, NO_2 (DT), PM_{10}	N
A3	Castlereagh Espie Way	Background	E 337347 N 371991	SO_2, PM_{10}	N
DT1	Cregagh Road	Roadside	E 336257 N 371278	NO_2 (DT)	N
DT2	Everton Drive	Background	E 336132 N 371141	NO_2 (DT)	N
DT3	Downshire Park East	Background	E 336474 N 371400	NO_2 (DT)	N
DT4	Upper Newtownards Road	Roadside	E 341991 N 374013	NO_2 (DT)	N
DT5	Newtownbreda Road	Roadside	E 335246 N 370061	NO_2 (DT)	N
DT6	Saintfield Road	Roadside	E 336832 N 365625	NO_2 (DT)	N

The automatic measurements of NO_x and PM_{10} were made using chemiluminescence analysers and the TEOM technique, respectively. Plots of the 2007 and 2008 measurements of NO_2 and PM_{10} can be found in Appendix A1. The TEOM data were reported as gravimetric equivalent using a factor of 1.3[2]. Details on the QA/QC arrangements are provided in Appendix A1.3. The diffusion tube measurements in 2007 and 2008 and information on the QA/QC arrangements are given in Appendix A2.

[1] Oxides of nitrogen (NO_x) is a collective term used to denote nitric oxide (NO) and nitrogen dioxide (NO_2). The chemiluminescence analyser determines the concentrations of NO and NO_x ($NO+NO_2$) and derives the concentration of NO_2 by difference. All references to the measurement of NO_x are taken to include the measurements of NO and NO_2.
[2] The volatile correction model was applied to the uncorrected data, as discussed in Appendix A.

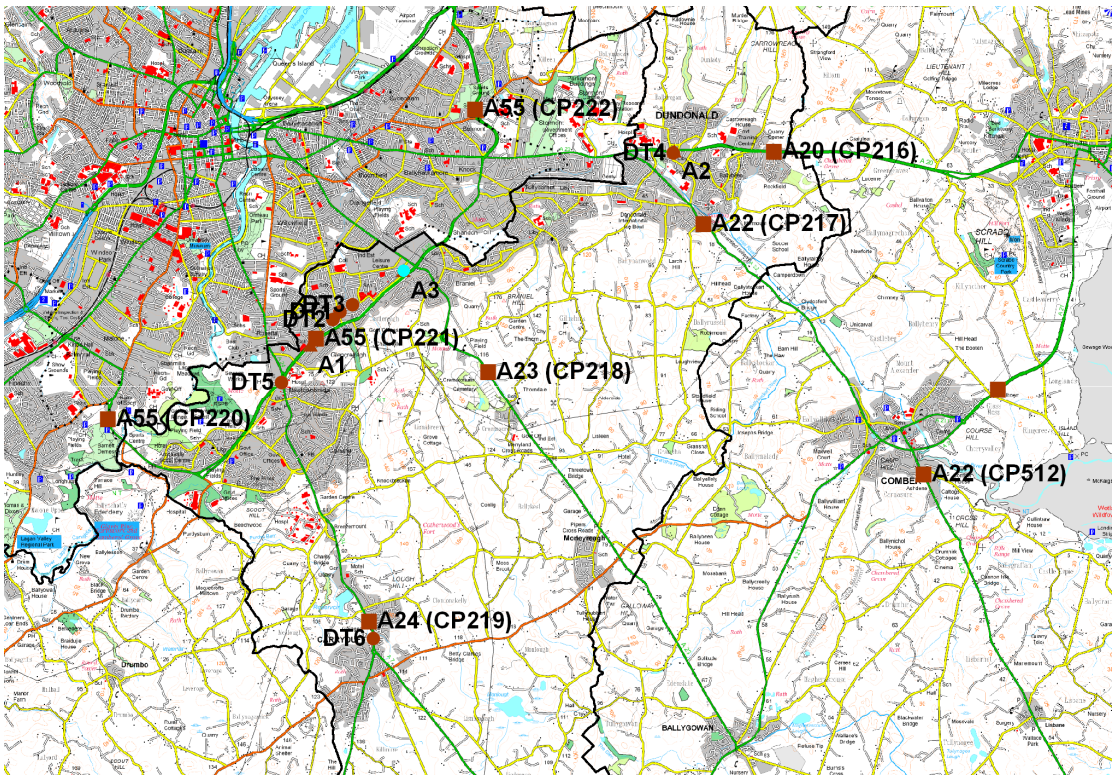


Figure 2-1: Overview map showing location of air pollution monitoring sites (circles and triangles) and traffic census points (squares) in and around Castlereagh Borough. The automatic sites are denoted by triangles [A1 = Lough View Drive, A2 = Dundonald and A3 = Espie Way] and the diffusion tube sites by circles [DT1 = Cregagh Road, DT2 = Everton Drive, DT3 = Downshire Park East, DT4 = Upper Newtownards Road, DT5 = Newtownbreda Road, DT6 = Saintfield Road].

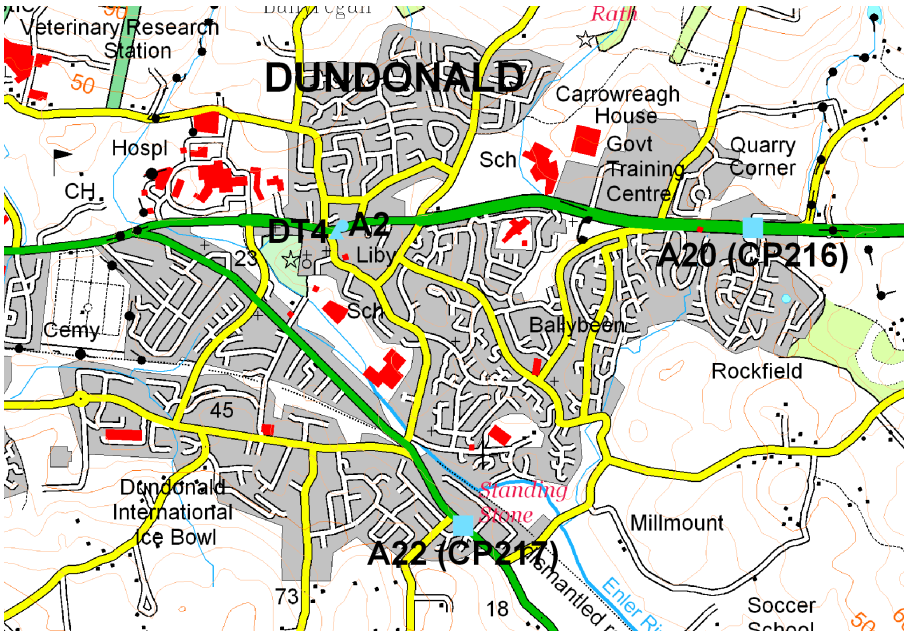


Figure 2-2: Detailed map showing air pollution monitoring sites (circles and triangles) and traffic census points (square) in and around Dundonald in Castlereagh Borough [Automatic Monitoring: A2 = Dundonald; Diffusion Tubes: DT4 = Upper Newtownards Road].

Triplicate diffusion tubes were co-located at both automatic-monitoring sites, thereby allowing adjustments to be made to the diffusion tube measurements. The triplicate measurements at the Castlereagh Dundonald automatic monitoring site commenced from March 2008. At the same time, the measurements at the Downshire Park East and the Upper Newtownards Road sites (DT3 and DT4) were stopped to provide the additional diffusion tubes needed for the triplicate measurements at the Dundonald automatic monitoring site. The closure of the Downshire Park East site was considered to be justified as there was another background site nearby (Everton Drive, DT2). The diffusion tube at the original site on the Upper Newtownards Road site was moved a short distance to be co-located with the Dundonald automatic monitoring site in March 2008. Following comment received on the 2008 progress report, monitoring was re-instated at the original site in October 2008 using triplicate diffusion tubes.

2.2 Monitoring Results and Statistics

In the following section, the measurements and derived statistics are presented for nitrogen dioxide (NO_2) and PM_{10}. The statistics are compared with the objectives for the different pollutants (see Table 1-1) to identify if there are exceedences.

2.2.1 Nitrogen Dioxide (Automatic Measurements)

Plots of the measured hourly mean NO_2 concentrations at the two automatic monitoring sites (Castlereagh Lough View Drive and Dundonald) for 2007 and 2008 can be found in Appendix A1. The Castlereagh Dundonald site was established in early 2007.

Table 2-2 presents the annual mean concentrations of NO_2 for the years from 2006 to 2008, determined at the two sites from the hourly measurements. Also shown is the number of hours when the hourly mean concentration exceeded the hourly mean objective of 200 μg m^{-3}. Currently, a maximum of 18 exceedences are permitted. There were no exceedences of either the annual mean or the hourly NO_2 air quality objectives in 2008, although the measurements at Castlereagh Dundonald in 2007 were close to the annual mean objective of 40 μg m^{-3}.

Table 2-2: Results of Automatic Monitoring for Nitrogen Dioxide: Comparison with Annual Mean Objective of 40 μg m^{-3}.

Site	Year	Annual mean concentrations (μg/m^3)	Number of Exceedences of hourly mean (200 μg/m^3)	Data Capture (%)
A1 Castlereagh Lough View Drive	2006	22.7	0	
	2007	22.5	0	96.3
	2008	21.8	0	95.3
A2 Castlereagh Dundonald	2006	-	-	-
	2007	38.8 (a)	2 (a)	78.7
	2008	32.3	3	99.6

(a) New site in 2007, measurements commenced in February.

2.2.2 Nitrogen Dioxide (Diffusion Tube Measurements)

The bias-adjusted monthly measurements for 2007 and 2008 can be found in Appendix A2. The adjusted annual mean concentrations and data capture (as number of valid months) for the different sites between 2006 and 2008 are presented in Figure 2-3. The results for the site at Upper Newtownards Road indicate exceedences of the annual mean NO_2 air quality objective of 40 μg m^{-3} in 2007 and 2008.

Figure 2-3 provides a graphical indication of the trend in the annual mean concentration over the longer period from 2001 to 2008. Only the measurements at the site on the Upper Newtownards Road are indicative of an exceedence of the annual mean objective.

Table 2-3: Results of Nitrogen Dioxide diffusion tubes for 2006-2008.

Site ID	Location	Within AQMA?	Annual mean concentrations ($\mu g/m^3$) Adjusted for bias		
			2006 *	2007 *	2008
Castlereagh DT1	Cregagh Road	N	23 (11)	27 (11)	26 (12)
Castlereagh DT2	Everton Drive	N	16 (11)	18 (12)	16 (11)
Castlereagh DT3	Downshire Park	N	13 (11)	16 (8)	*- (2) (b)*
Castlereagh DT4	**Upper Newtonards Road**	**N**	**40 (12)**	**48 (12)**	***55 (5) (c)***
Castlereagh DT5	Newtownbreda Road	N	32 (12)	34 (12)	35 (12)
Castlereagh DT6	Saintfield Road	N	15 (12)	17 (12)	17 (12)

Notes to Table 2.3: (a) The number in bracket indicates the number of valid monthly measurements; (b) Diffusion tube measurements were only made in January and February as the diffusion tubes for this site were used to make triplicate measurements at the Castlereagh Dundonald automatic site; (c) Diffusion tube measurements were only made for January-February and October-December 2008 as the tube was moved to the nearby Castlereagh Dundonald automatic site. The ratio of the period mean concentration to annual mean concentration was found to be 1.17 from automatic measurements made in Belfast and the Eastern group (see Appendix B2, section B.2.3.4 in USA, 2009). The entry shows the estimated annual mean concentration (period mean concentration).

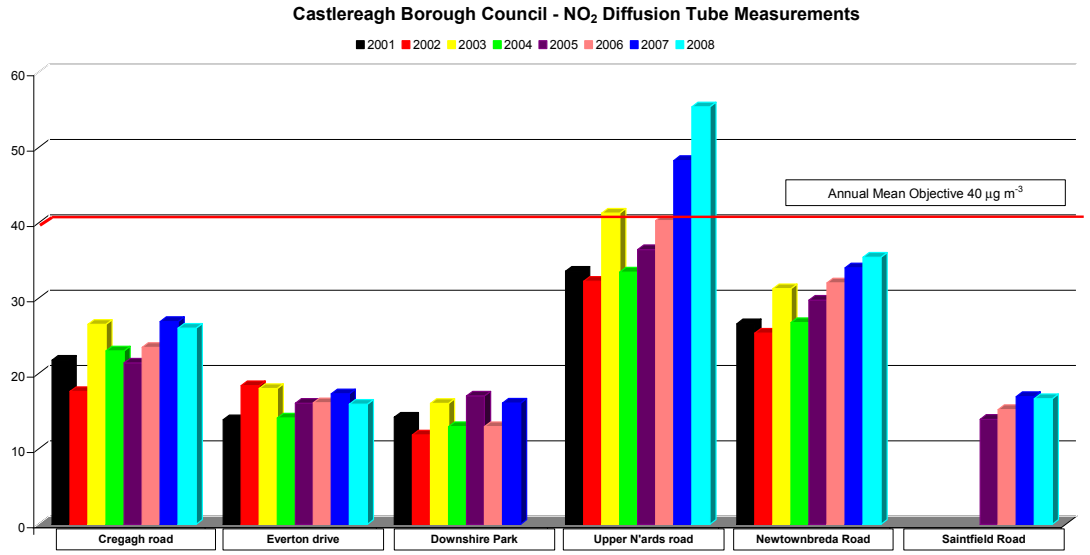


Figure 2-3: Trends in the measured annual mean NO_2 concentrations (in $\mu g\ m^{-3}$) at diffusion tube sites in Castlereagh.

2.2.3 PM_{10}

Plots of the hourly mean PM_{10} concentrations measured at the automatic monitoring sites in 2007 and 2008 can be found in Appendix A1. The Castlereagh Dundonald site was established in early 2007 and prior to that date, PM_{10} measurements were made at the Castlereagh Espie Way site.

TEOM measurements of PM_{10} are known to under-read with respect to the reference gravimetric method. Until recently, a default correction of 1.3 was applied to TEOM data in order to generate a nominal "gravimetric-equivalent result" [paragraph 3.34 in TG (2009)]. This factor has been used by AEA Technology to convert the Castlereagh TEOM data into gravimetric equivalents.

The latest technical guidance [TG, 2009] recommends the use of the Volatile Correction Model (VCM) developed by King's College London. The volatile correction model uses measurements of the volatile PM_{10} component made using FDMS TEOM instruments, located within 130 km of the site. As discussed in the 2009 updating and screening assessment [USA, 2009], the only operational site in 2008 was that at Lisburn Dunmurry High School (from the end of February). With the lower data capture and to ensure consistency with the previous years, the exceedence statistics presented in Table 2-4 were based on the scaling factor of 1.3.

Table 2-4: Results of PM_{10} Automatic Monitoring - Comparison with Annual Mean Objective of 40 μg m^{-3}.

Site	Year	Annual mean concentrations (μg/m^3)	Number of Exceedences of daily mean (50 μg/m^3)	Data Capture (%)
A1 Castlereagh Lough View Drive (gravimetric – note a)	2006	22.4	4	
	2007	22.1	3	97.9
	2008	21.2	0	91.6
A2 Castlereagh Dundonald (gravimetric)	2006	-	-	-
	2007	22.1 (b)	1 (b)	69.5
	2008	22.8	4	98.1
A3 Castlereagh Espie Way (gravimetric)	2006	22.7	5	
	2007	- (c)	- (c)	-
	2008	-	-	-

(a) TEOM PM_{10} measurements converted to gravimetric equivalent using a factor of 1.3; (b) New site in 2007, measurements commenced in April; (b) Site closed in 2007.

Table 2-4 compares the annual mean concentrations of PM_{10} determined at the sites for the years 2006-2008 with the annual mean objective of 40 μg m^{-3}. There were no exceedences of the annual mean objective. Table 2-4 also presents the number of days at the automatic sites for 2006-2008 when the daily mean PM_{10} concentration exceeded 50 μg m^{-3}. Currently, a maximum of 35 exceedences are permitted per year. There were therefore no exceedences of the daily mean PM_{10} objective.

3 Dispersion Modelling

The diffusion tube measurements made on the A20 Upper Newtownards road in Dundonald have indicated the possibility of exceedences of the NO_2 annual mean objective. The Castlereagh Dundonlald automatic monitoring site, which is located in the vicinity, has not indicated any exceedences of the annual mean objective in either 2007 or 2008. However, the diffusion tube site is located both closer to the kerb and to the queuing traffic on the westbound carriageway.

The detailed modelling assessment made use of the ADMS ROADS dispersion model (CERC, 2006). The emissions from road traffic on the A20 were modelled explicitly. The emissions from minor roads and other sources were assumed to form part of the background concentrations.

3.1 The ADMS-ROADS Dispersion Model

ADMS ROADS (version 2.3), developed by Cambridge Environmental Research Consultants (http://www.cerc.co.uk/software/admsroads.htm), is an advanced dispersion model for investigating air pollution problems due to industrial sites and networks of roads. The code contains an integrated street canyon module based on the Danish OSPM traffic model. The ADMS ROADS model has been extensively used in regulatory applications in the United Kingdom and elsewhere (see references within the ADMS ROADS User Guide [CERC, 2006]).

The model contains an interface to ESRI's ARCMAP Geographic Information System, allowing the model to be run from ARCMAP and the model results to be presented as pollutant concentration contours superimposed on a map of the area of interest.

3.2 The Model Domain

A detailed street map of the A20 Upper Newtownards road in Dundonald is shown in Figure 3-1.

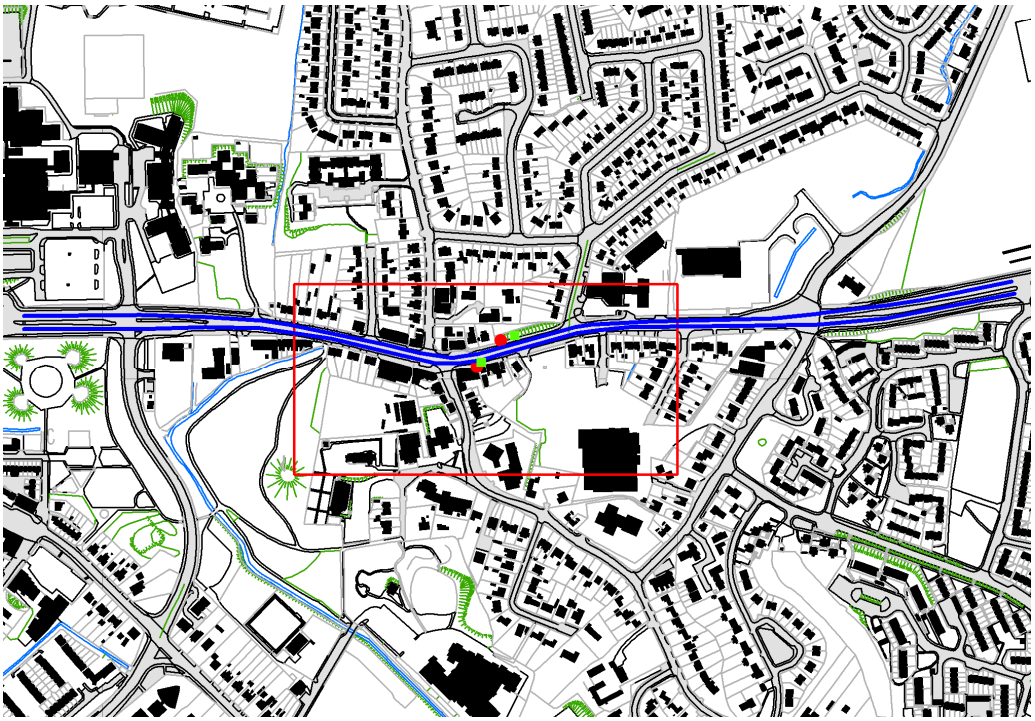


Figure 3-1: Ordnance Survey Northern Ireland street map of the A20 Upper Newtownards Road near Normandy Court in Dundonald. Superimposed on the map are (a) the model domain (red square), (b) the modelled road links (blue lines) and the original (red circles) and modified (green squares) locations of the monitoring sites.

Superimposed on the map are:

- The modelled road links (blue lines)
- The model domain (red square). The model domain was defined by the grid co-ordinates: lower left (341800,373900), upper right (342200,374100). A spatial resolution of 5 m was used.
- The original (red circles) and modified (green squares) locations of the Castlereagh Dundonald automatic and Upper Newtownards Road diffusion tube sites:
  - Castlereagh Dundonald (original map ref: 342016, 374041; modified map reference 342031, 374046)
  - Upper Newtownards Road diffusion tube site (original map ref: 341991, 374013; modified map reference 341996, 374018)

  The locations of the monitoring sites were slightly modified. The automatic monitoring site is located opposite the road junction and the diffusion tubes are mounted on a lamppost close to the kerbside, instead of next to the façade of the building.

The co-ordinates of specific receptor sites, representing houses, are presented in Table 3-1 and are labelled on the expanded map of the modelling domain, shown in Figure 3-2.

Table 3-1: Grid references of specific receptor sites used in the modelling

Receptor	Easting	Northing
R01	341991	373964
R02	341988	373971
R03	341986	373976
R04	341983	373983
R05	341981	374012
R06	342090	374037
R07	342098	374035
R08	342108	374035

Receptor	Easting	Northing
R09	342133	374039
R10	342139	374039
R11	342149	374040
R12	341962	374045
R13	341984	374038
R14	341988	374039
R15	342000	374041
R16	342074	374064

Figure 3-2: Location of the receptor sites.

3.3 Input Data

The dispersion model requires data on:

- the characteristics of the emission sources (*e.g.*, road layout, traffic flow, vehicle composition)
- the emissions (magnitude and temporal profile)
- background concentrations
- meteorology

The input data used for these are described further in the following sections.

3.3.1 Road layout, traffic flow and vehicle composition

The A20 is an arterial route passing through Castlereagh Borough between the city of Belfast and Newtownards to the east of Belfast. As traffic count information was available separately for east (out of Belfast) and west bound (to Belfast) traffic [DRDNI, 2008], these were modelled separately. The portion of the A20 shown in Figure 3-1 was split into 6 links in each direction to allow for changes in speed, road width and canyon heights. Each link was comprised of a number of linear segments. The co-ordinates of these segments were defined using ARCMAP and can be found in Tables B.1a and B.1b in Appendix B. These tables also contain information on the elevation, road width, any canyon heights and the speeds assumed.

The applicable speed limits on the A20 in Dundonald is 30 mph and 40 mph on the stretch of dual carriageway to shown to the right of the model domain in Figure 3-1. In reality, the actual speeds are lower, especially around the junction in the middle of Figure 3-1 and during the rush hour period. The speeds used in this study were based on a survey conducted by Castlereagh Borough Council for the Detailed Assessment.

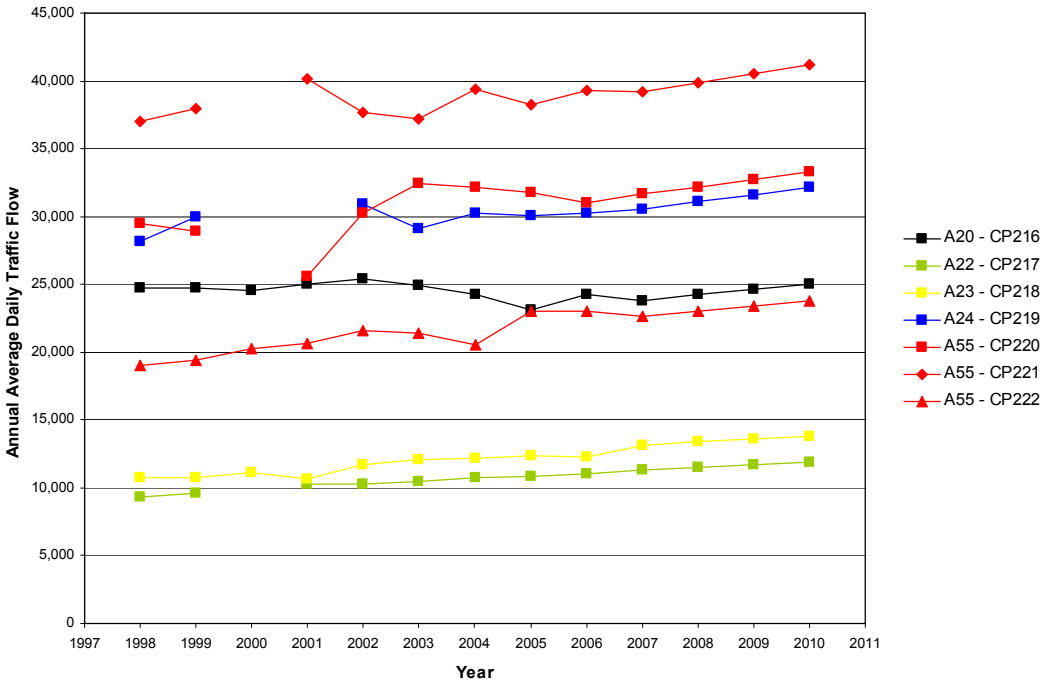


Figure 3-3: Time series of actual and forecast traffic counts (7-day AADT) at traffic census points in and around Castlereagh Borough.

Traffic count information was available separately for east (out of Belfast) and west bound (to Belfast) traffic from traffic census point 216 (see Tables B.2 and B.4 of Appendix B). This census point (A20 East Upper Newtownards Road, Belfast (at Quarry Inn]) lies a few kilometres to the east of Dundonald (see Figure 2-2). Vehicle composition data are also provided at this census point (Table B.2). Figure 3-3 shows a time series of the actual and forecast traffic counts (AADT, 7-day average) at this and other traffic census points in and around Castlereagh Borough:

- A22 East Comber Road, Belfast (south east of New Line)
- A23 East Ballygowan Road, Belfast (at Roselawn)
- A24 East Belfast, Carryduff (at Baronscourt)
- A55 East Upper Knockbreda Road Belfast

The actual traffic counts (1998-2007) were provided by Roads Services of the Northern Ireland Department for Regional Development (DRD, 2008) and are provided in Table B.4 of Appendix B. The traffic counts for 2008-2010 were derived using the automated traffic growth calculator available on the LAQM webpage (Table B.3).

It can be seen that the actual traffic flows between 1997 and 2007 on the A20 in Dundonald showed relatively little change.

3.3.2 Emission Factors

The ADMS-Roads dispersion model has in built vehicle emission factors based on the 1999 or 2003 DMRB[3] databases available in the model or it can use those provided by the user. The DMRB databases have further options to specify the type of road (urban, rural, motorway) and the year (to reflect the introduction of vehicle emission abatement standards on the vehicle fleet), which affect the actual emission factors used. For this study, the emission factors were based on the 2003 DMRB database and calculated for the number of cars/light goods and buses/heavy goods vehicles specified for the road link for an urban road type for the years 2007, 2008 or 2010.

3.3.3 Temporal Emission Factors

Each road link was further split to take account of the different traffic densities during the rush hour periods and at other times, as shown in Table 3-2. The traffic counts for these 4 periods (AM, Int, PM and Night) were derived as follows. The counts for the rush hour periods were taken to be the number of vehicles recorded for the peak periods (Table 5B in DRDNI, 2008). The NO_x temporal emission profile for the UK used in the EMEP UNIOZONE mesoscale model (see Table B.5 of Appendix B) was combined with the 5-day AADT to give an hourly number of counts for the non-rush hour periods of the day (having removed the rush hour periods). The hourly counts were then simply averaged to give the traffic counts for light and heavy good vehicles for the two non-rush hour periods. The growth factors given in Table B.3 for the cars/light goods and heavy goods vehicles were applied to give the corresponding traffic counts in future years. The traffic counts for these 4 periods (AM, Int, PM and Night) can be found in Table B.6a of Appendix B.

Table 3-2: Periods covered by the 4 different traffic conditions.

Period	Designation	Time of Day
Morning rush hour	East_x_AM, West_x_AM	07:00-09:00
Between rush hours	East_x_Int, West_x_Int	09:00-15:00
Afternoon rush hour	East_x_PM, West_x_PM	15:00-18:00
Evening/Night	East_x_Night, West_x_Night	18:00-07:00

The vehicle composition at the traffic counting point is given as 96.7% cars/light goods and 3.3% heavy goods vehicles (see Table B.2). In an earlier Stage 2/3 assessment for Castlereagh Borough Council (CBC, 2004), a higher percentage (8%) of the vehicles were assumed to be buses and heavy goods vehicles and this was considered by council staff to be the more appropriate figure. Vehicle counts were also derived for this higher fraction of buses and heavy goods vehicles (see Table B.6b in Appendix B).

3.3.4 Background Concentrations

Background concentrations of NO_x and PM_{10} for the grid squares containing the monitoring locations in Dundonald. The 'background' concentration were taken from the maps available on the LAQM page of the National Air Quality archive. The maps provided information on the contribution of different sources (motorways, trunk roads, primary A roads and minor roads, industrial, domestic, etc).

[3] Design Manual for Roads and Bridges.

The contribution from the in-square primary A roads was excluded to avoid double counting. The background concentrations used can be found in Table 3-3.

Table 3-3: Background concentrations

Location/ Receptor	Grid Ref	Background Concentrations (in μg m^{-3})			
		Year	NO_x	NO_2	PM_{10}
Castlereagh Dundonald Automatic Monitoring Site	E 342016 N 374041	2007	13.60 (13.83)	(a)	17.64 (17.65)
		2008	12.92 (13.13)	(a)	17.45 (17.46)
		2010	11.54 (11.73)	(a)	17.07 (17.08)
Upper Newtownards Road Diffusion Tube Site	E 341991 N 374013	2007	12.52 (12.84)	(a)	17.67 (17.69)
		2008	11.92 (12.22)	(a)	17.49 (17.52)
		2010	10.98 (10.71)	(a)	17.14 (17.17)
Average		2007	13.1	(a)	17.7
		2008	12.4	(a)	17.5
		2010	11.3	(a)	17.1

Notes (a) As per the Technical Guidance [TG.09, 2009], the spreadsheet tool was used to calculate the roadside and background NO_2 concentrations using the oxidant partitioning approach.

3.3.5 Meteorological Data

The ADMS-ROADS dispersion model can calculate distributions of pollutant concentrations for the specified model domain from hourly sequential meteorological data (and averages over the period modelled).

Hourly sequential meteorological data were obtained from the Met Office for the meteorological station at Belfast Aldergrove for the years 2007 and 2008. This station is located circa 23km away from Castlereagh. The dataset was supplied in a format that could be used directly in the ADMS ROADS dispersion model. Meteorological data from this station was also used in the previous Stage 2/3 assessment [CBC, 2003, 2004].

ADMS ROADS uses standard algorithms to calculate the boundary layer meteorological parameters required by the dispersion model [see ADMS ROADS User Guide (CERC, 2006) and references therein]. In processing the data, the module checks that the input data lie within specified limits. Warning or error messages are provided as appropriate.

Figure 3-4 shows the wind rose derived for Belfast Aldergrove from the 2007 and 2008 meteorological data. As expected, the most common wind directions are from the South West to West sector (230°-270°).

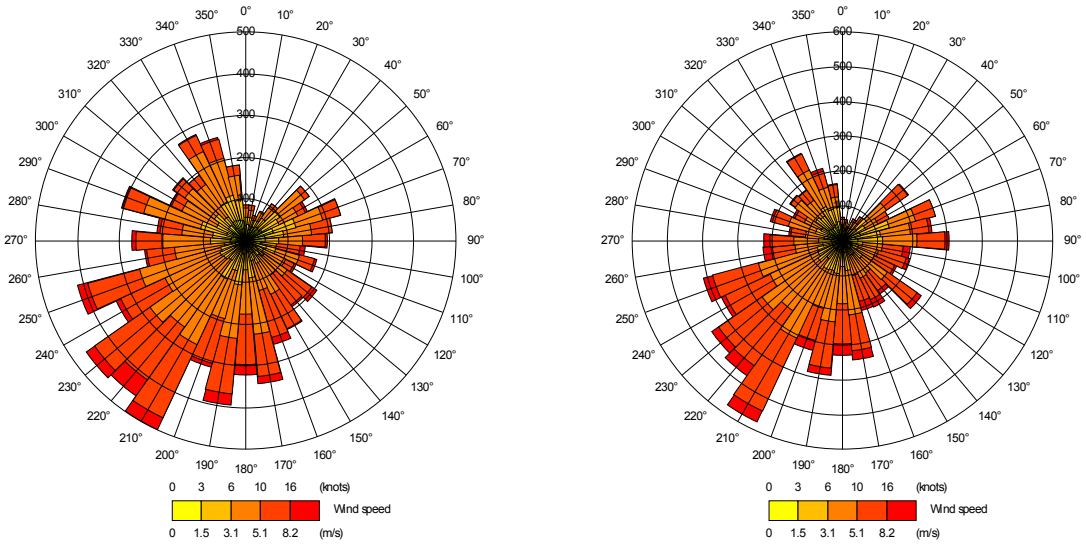


Figure 3-4: Wind Roses for 2007 and 2008 from the Belfast Aldergrove Met Station.

4 Results

4.1 Model Runs

The model runs undertaken are listed in Table 4-1 with the key assumptions made. Concentrations were calculated for both short-term (i.e., hourly) and long-term (i.e., annual) exposure.

Table 4-1: Overview of ADMS Model Runs and Model Assumption.

Run	Emission Factors	Vehicle Composition %LGV	Vehicle Composition %HGV	Meteorology
1. 2007	DMRB 2003 Urban, 2007	96.70	3.30	2007 Hourly
2. 2007	DMRB 2003 Urban, 2007	92.00	8.00	2007 Hourly
3. 2008	DMRB 2003 Urban, 2008	96.72	3.28	2008 Hourly
4. 2008	DMRB 2003 Urban, 2008	92.00	8.00	2008 Hourly
5. 2010	DMRB 2003 Urban, 2010	96.75	3.25	2008 Hourly
6. 2010	DMRB 2003 Urban, 2010	92.00	8.00	2008 Hourly

As indicated in Section 3.3.3, traffic counts were derived for (a) the vehicle composition recorded at the traffic counting point [96.7% cars/light goods and 3.3% heavy goods vehicles] and (b) the higher percentage (8%) of the vehicles used in an earlier Stage 2/3 assessment (CBC, 2004). Model runs were undertaken for both cases.

4.2 Model Verification

Measurements from the automatic monitoring and diffusion tube sites in Dundonald have been used to verify the model results. The purpose of this verification and adjustment has been to ensure that the modelled concentrations reproduce the measured values at the monitoring locations. Details of the derivations of the model adjustment factor and the overall modelled annual mean concentrations of NO_2 and PM_{10} are given in Tables B.7 and B.8 of Appendix B for the two vehicle composition cases. The model verification and adjustment process followed the latest technical guidance [TG, 2009].

As local council officers considered the higher figure to be realistic, results are only presented here (and subsequently) for the 8% case. Table 4-2 compares the modelled annual mean NO_2 concentrations with those observed at the Dundonald monitoring sites in 2007 and 2008. Table 4-3 provides the corresponding comparison of the modelled and observed annual mean PM_{10} concentrations.

Table 4-2: Comparison of modelled annual mean NO_2 concentrations (in $\mu g\ m^{-3}$) with those observed at the Dundonald monitoring sites in 2007 and 2008.

Site	Year	Annual Mean Concentration (in $\mu g\ m^{-3}$)		Percentage Difference
		Observed	Modelled	
Automatic Monitoring Site	2007	38	34.8	-8.3%
	2008	32	34.2	6.8%
Diffusion Tube site	2007	48	56.4	17.4%
	2008	55	55.4	0.7%

Table 4-3 Comparison of modelled annual mean PM_{10} concentrations (in µg m^{-3}) with those observed at the Dundonald monitoring sites in 2007 and 2008.

Site	Year	Annual Mean Concentration (in µg m^{-3})		Percentage Difference
		Observed	Modelled	
Automatic Monitoring Site	2007	22.1	22.7	2.7%
	2008	22.8	22.2	-2.5%

A percentage difference of 25% or less is commonly used as an acceptable level of model performance (see for example the Detailed Assessment prepared for Mid Bedfordshire District Council). *It is noted that there are no other measurements to provide an independent verification*.

4.3 Predicted concentrations at receptors

In a similar manner, the annual mean concentrations of NO_2 at the selected receptor sites were derived for 2008 from the adjusted annual mean NO_x concentrations calculated for the modelled road emissions and the assumed background NO_x concentration using the NO_x to NO_2 conversion tool available on the LAQM website. The conversion tool provides the roadside and background contributions, which have been summed to give the total annual mean concentration, as shown in Table 4-4. The table also includes the total, the adjusted modelled road and background annual mean concentrations for 2008 for PM_{10}.

Table 4-4 shows that only one of the selected receptor locations (R05) exceeds the annual mean air quality objective for NO_2 of 40 µg m^{-3}. **This is the receptor at the façade of Normandy Court**. There are no exceedences of the air quality objective for PM_{10} at any of the locations. The same conclusion can be drawn from calculations for 2007 and 2010, as shown in Table B.9 of Appendix B.

A contour plot of the modelled annual mean NO_2 concentration for 2008 is shown in Figure 4-1. The modelled concentrations above the objective are shown in red and are largely confined to the area of the road. The highest concentrations are in the vicinity of Normandy Court where there is a street canyon and the traffic speeds are slowest. The corresponding plots for 2007 and 2010 show a similar pattern (see Figure B.1 of Appendix B) although the area of exceedence is smaller for the 2010 case.

Figure 4-1: Contour plot of the modelled annual mean NO_2 concentration (in µg m^{-3}) for 2008.

Table 4-4: Adjusted roadside and total annual mean NO_x and PM_{10} concentrations as calculated using ADMS-Roads for selected receptor locations in Dundonald for 2008 and the derived annual mean NO_2 concentrations.

2008	Annual Mean NO_x Concentration (in µg m^{-3} as NO_2)			Annual Mean NO_2 Concentration (in µg m^{-3})			Annual Mean PM_{10} Concentration (in µg m^{-3})		
Receptor	**Total**	**Road**	**Background**	**Total**	**Road**	**Background**			
R01	27.2	14.8	12.4	15.4	6.8	8.6	18.6	1.1	17.5
R02	29.4	17.0	12.4	16.3	7.8	8.5	18.8	1.3	17.5
R03	31.4	19.0	12.4	17.2	8.7	8.6	18.9	1.4	17.5
R04	35.2	22.8	12.4	18.8	10.2	8.6	19.2	1.7	17.5
R05	**166.1**	**153.7**	**12.4**	**52.8**	**44.2**	**8.5**	29.4	11.9	17.5
R06	66.1	53.7	12.4	30.0	21.5	8.6	21.4	3.9	17.5
R07	56.6	44.2	12.4	26.9	18.4	8.5	20.7	3.2	17.5
R08	53.2	40.8	12.4	25.7	17.2	8.5	20.4	2.9	17.5
R09	55.0	42.6	12.4	26.3	17.8	8.5	20.6	3.1	17.5
R10	54.0	41.6	12.4	26.0	17.4	8.6	20.5	3.0	17.5
R11	54.5	42.1	12.4	26.2	17.6	8.5	20.5	3.0	17.5
R12	57.0	44.6	12.4	27.0	18.5	8.5	20.9	3.4	17.5
R13	81.7	69.3	12.4	34.7	26.1	8.6	22.8	5.3	17.5
R14	78.7	66.3	12.4	33.8	25.3	8.5	22.5	5.0	17.5
R15	74.4	62.0	12.4	32.6	24.1	8.5	22.1	4.6	17.5
R16	58.5	46.1	12.4	27.5	19.0	8.5	20.8	3.3	17.5

5 Conclusions and Recommendations

5.1 Conclusions

A detailed assessment has been carried out for the A20 Upper Newtownards Road, in the vicinity of Normandy Court in Dundonald, where exceedences of the annual mean NO_2 objective have been observed. NO_2 and PM_{10} concentrations have been predicted at relevant receptors in the vicinity of Normandy Court in Dundonald.

The model results have been verified against automatic monitoring and diffusion tube measurements for NO_x, NO_2 and PM_{10} within the vicinity of the modelled road links. The model results suggest that the annual mean objective for NO_2 is not likely to be met at the worst-case receptors in 2007, 2008 and subsequent years modelled. There are no predicted exceedences of the air quality objective for PM_{10} at any of the locations.

5.2 Recommendations

Based on this detailed assessment and review of the monitoring data within the areas under assessment, the following two recommendations are made to Castlereagh Borough Council:

1. To consider declaration of an Air Quality Management Area in the A20 Upper Newtownards Road, in the vicinity of Normandy Court in Dundonald, on the basis of NO_2, where exceedences of the annual mean objective are predicted at relevant receptor locations;
2. To continue monitoring NO_2 (and PM_{10}) at the current monitoring locations in order to ensure that any future changes in air quality are detected, notably locations representative of relevant exposure, i.e. at the façade of residential properties.

6 References

CBC (2003) **Second/third stage review and assessment of local air quality**. Interim Report prepared by the Environmental Health Department, Castlereagh Borough Council (December 2003).

CBC (2004) **Third stage air quality review and assessment**. Report prepared by the Environmental Health Department, Castlereagh Borough Council (July 2004).

CERC (2006) **ADMS-Roads: An Air Quality Management System, User Guide**. Cambridge Environmental Research Consultants.

Defra (2007) **Evaluation of support provided by Defra and the Devolved Administrations to Local Authorities for air quality reviews and assessments (2004-2007)**. Report prepared for Defra and the Devolved Administrations by the Air Quality Management Resource Centre (University of the West of England) and Air Quality Consultants Ltd, May 2007.

DRDNI (2008) **Traffic and travel information 2007 incorporating annual traffic census and vehicle kilometres of travel**. Report prepared by the Roads Service, Northern Ireland Department for Regional Development.

MB (2008) **LAQM Detailed Assessment for Mid Beds District Council**. Technical Report No: ADIX0562/BV/AQ prepared by Bureau Veritas, June 2008.

EG (2008) **Eastern Group Air Quality Progress Report**. Annual report on air quality in the Eastern group of local authorities in Northern Ireland, April 2008.

PG (2003) **Part IV of the Environment Act 1995. Local Air Quality Management: Technical Guidance LAQM.TG(03)**. Policy guidance prepared by the Department for Environment, Food and Rural Affairs and the Devolved Administrations, February 2003.

TG (2003) **Part IV of the Environment Act 1995. Local Air Quality Management: Technical Guidance LAQM.TG(03)**. Technical guidance prepared by the Department for Environment, Food and Rural Affairs and the Devolved Administrations, January 2003.

TG (2009) **Part IV of the Environment Act 1995. Local Air Quality Management: Technical Guidance LAQM.TG(09)**. Technical guidance prepared by the Department for Environment, Food and Rural Affairs and the Devolved Administrations, February 2009.

USA (2006) **Air Quality Update and Screening and Assessment**. A report (ED 42019001 Issue 1) prepared for Castlereagh Borough Council by AEA Technology, May 2006.

USA (2009) **Air Quality Update and Screening and Assessment**. A report (NPL AS 35) prepared for Castlereagh Borough Council by the National Physical Laboratory, April 2009.

Appendices

Appendix A: Air Pollution Monitoring Data

Appendix A1: 2008 air pollution measurements

Appendix A2: QA/QC information

Appendix B: Dispersion Modelling

Appendix A: Air Pollution Measurements

Appendix A1 – Automatic Measurements

- Automatic measurements of NO, NO_2, NO_x and PM_{10}[4] at Castlereagh Lough View Drive (see Appendix A1.1)
- Automatic measurements of NO, NO_2, NO_x and PM_{10} at Castlereagh Dundonald Drive (see Appendix A1.2)
- QA/QC Procedures and PM_{10} Adjustment (Appendix A1.3)

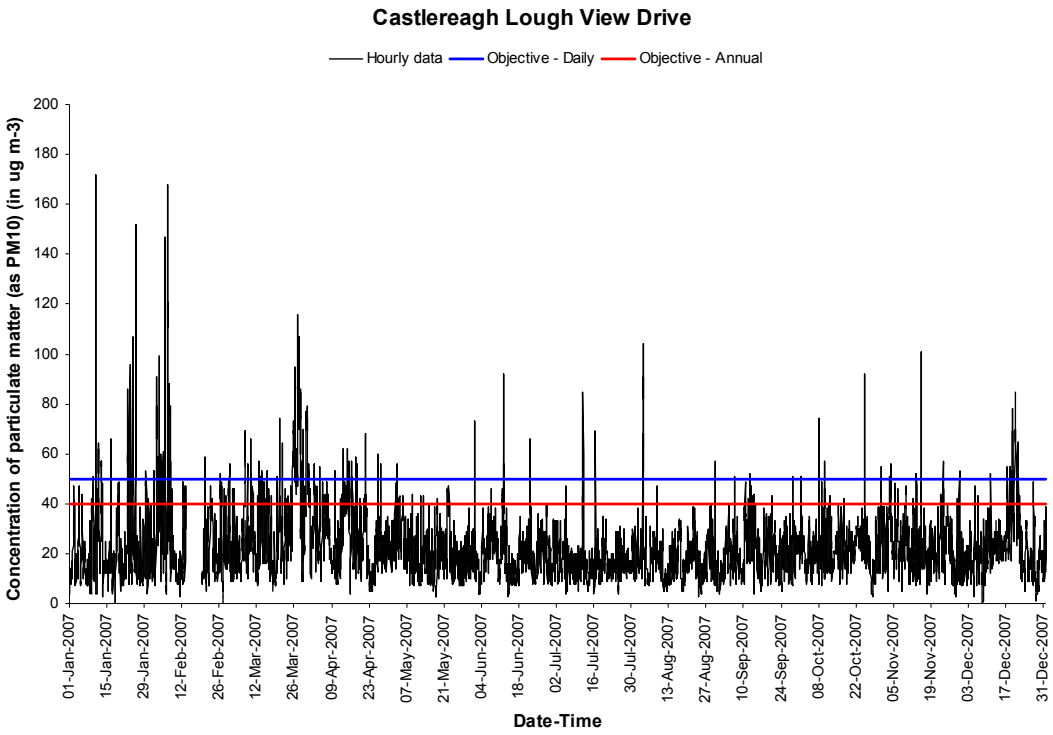
Appendix A2 – Diffusion Tube Measurements

- Diffusion tube measurements of NO_2 (see Appendix A2.1) from
  - Cregagh Road (single tube)
  - Everton Drive (single tube)
  - Downshire Park (single tube to February 2008)
  - Upper Newtownards Road (single tube to February 2008, three tubes from October 2008)
  - Newtownbreda Road (single tube)
  - Saintfield Road (single tube)

Appendix A2.2 provide information on the QA/QC procedures and bias adjustment applied to the diffusion tube measurements.

[4] The PM_{10} measurements were reported as gravimetric equivalent using a factor of 1.3. As discussed in Section B2.2, the volatile correction model of King's College London has been used to correct the raw 2008 PM_{10} measurements.

A1.1 - Automatic Measurements at Castlereagh Lough View Drive



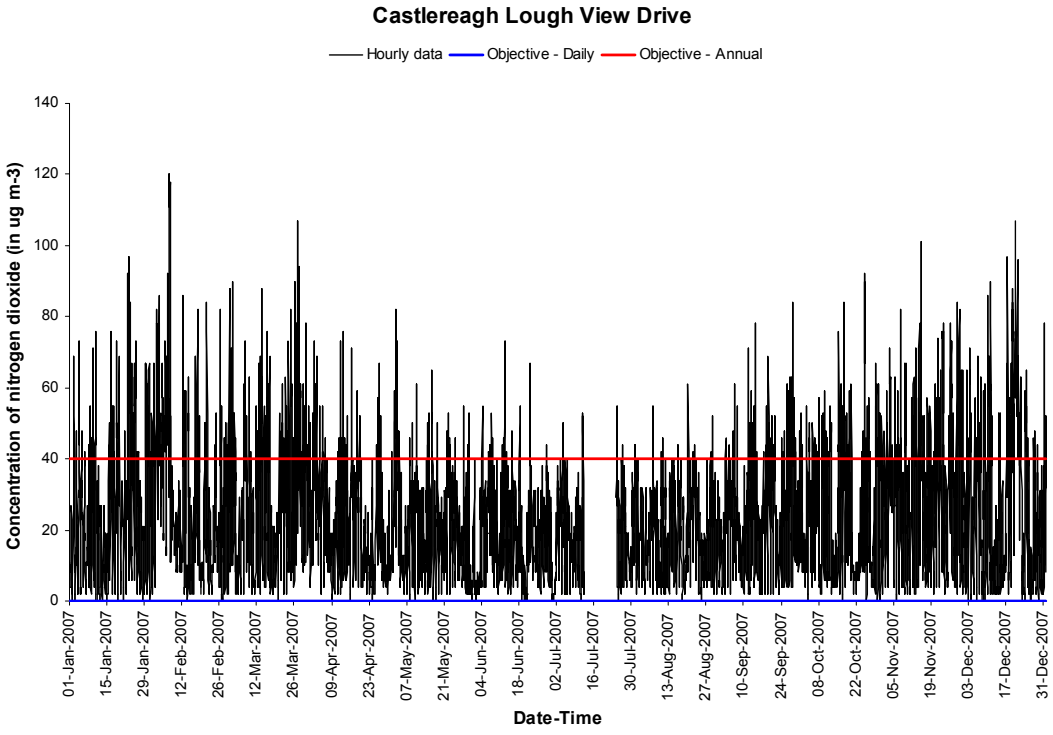


Figure A1.1: 2007 hourly measurements of nitrogen dioxide (in µg NO_2 m^{-3}, upper panel) and of particulate matter (as PM_{10} in µg m^{-3}, lower panel) for the Castlereagh Lough View Drive site.

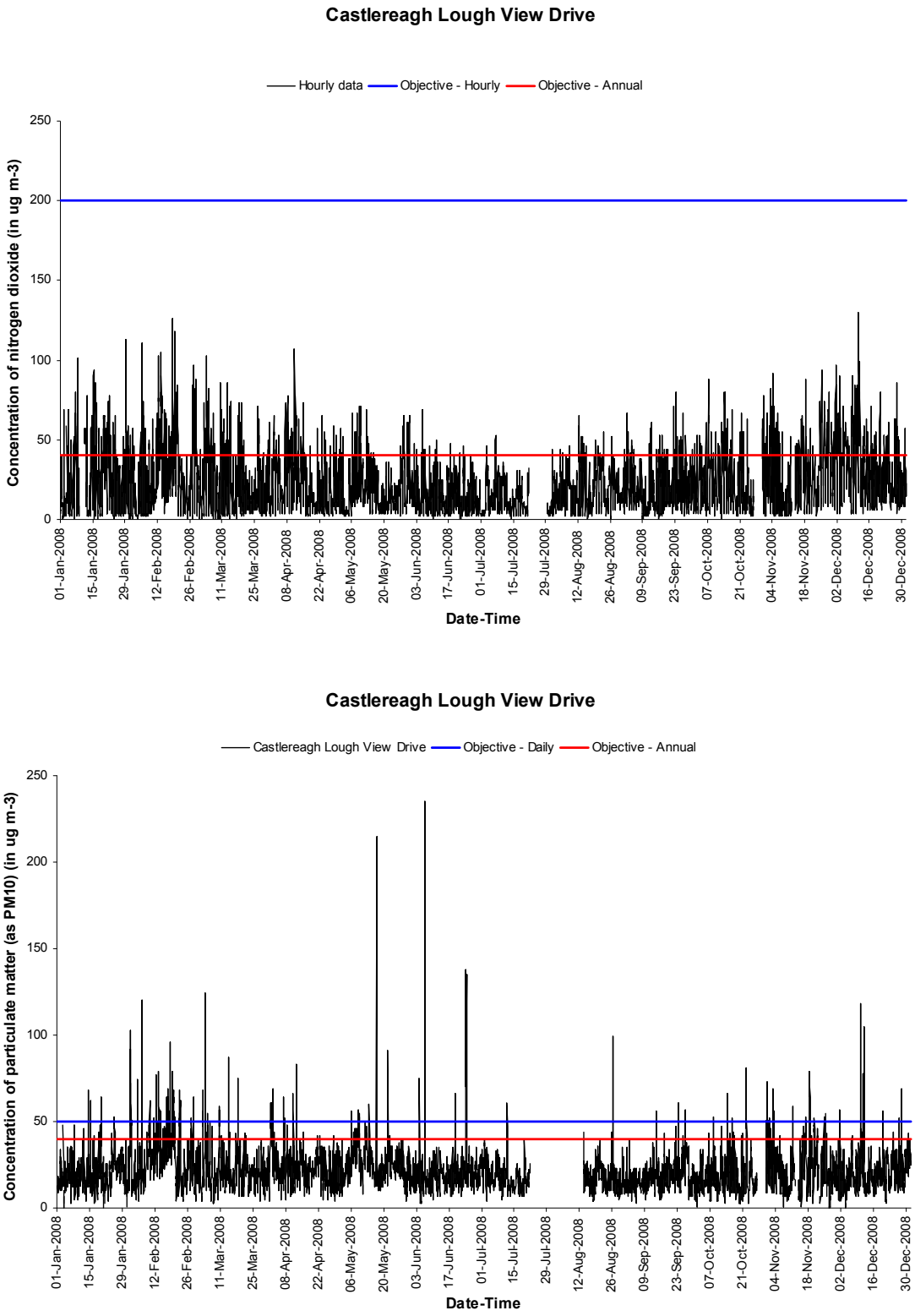


Figure A1.2: 2008 hourly measurements of nitrogen dioxide (in µg NO_2 m^{-3}, upper panel) and of particulate matter (as PM_{10} in µg m^{-3}, lower panel) for the Castlereagh Lough View Drive site.

Statistics: Castlereagh Lough View Drive

These data have been fully ratified by AEA Technology

(a) 1st January to 31st December 2007

Pollutant	PM_{10}*+	NO	NO_2	NO_X
Number Very High	0	-	0	-
Number High	0	-	0	-
Number Moderate	30	-	0	-
Number Low	8574	-	8435	-
Maximum 15-minute mean	267 µg m^{-3}	551 µg m^{-3}	149 µg m^{-3}	991 µg m^{-3}
Maximum hourly mean	172 µg m^{-3}	446 µg m^{-3}	120 µg m^{-3}	793 µg m^{-3}
Maximum running 8-hour mean	94 µg m^{-3}	249 µg m^{-3}	78 µg m^{-3}	457 µg m^{-3}
Maximum running 24-hour mean	85 µg m^{-3}	116 µg m^{-3}	67 µg m^{-3}	242 µg m^{-3}
Maximum daily mean	80 µg m^{-3}	94 µg m^{-3}	57 µg m^{-3}	190 µg m^{-3}
Average	22 µg m^{-3}	13 µg m^{-3}	23 µg m^{-3}	42 µg m^{-3}
Data capture	97.9 %	96.3 %	96.3 %	96.3 %

Pollutant	Air Quality Regulations (Northern Ireland) 2003	Exceedences	Days
PM_{10} Particulate Matter (Gravimetric)	Daily mean > 50 µgm^{-3}	0	-
PM_{10} Particulate Matter (Gravimetric)	Annual mean > 40 µgm^{-3}	0	0
Nitrogen Dioxide	Annual mean > 40 µgm^{-3}	3	3
Nitrogen Dioxide	Hourly mean > 200 µgm^{-3}	0	-

(b) 1st January to 31st December 2008

Pollutant	PM_{10}*+	NO	NO_2	NO_X
Number Very High	0	-	0	-
Number High	0	-	0	-
Number Moderate	0	-	0	-
Number Low	8045	-	8369	-
Maximum 15-minute mean	859 µgm^{-3}	461 µgm^{-3}	147 µgm^{-3}	838 µgm^{-3}
Maximum hourly mean	235 µgm^{-3}	390 µgm^{-3}	130 µgm^{-3}	722 µgm^{-3}
Maximum running 8-hour mean	72 µgm^{-3}	186 µgm^{-3}	86 µgm^{-3}	370 µgm^{-3}
Maximum running 24-hour mean	51 µgm^{-3}	99 µgm^{-3}	66 µgm^{-3}	216 µgm^{-3}
Maximum daily mean	47 µgm^{-3}	97 µgm^{-3}	65 µgm^{-3}	210 µgm^{-3}
Average	21 µgm^{-3}	11 µgm^{-3}	22 µg m^{-3}	39 µgm^{-3}
Data capture	91.6 %	95.3 %	95.3 %	95.3 %

Pollutant	Air Quality Regulations (Northern Ireland) 2003	Exceedences	Days
PM_{10} Particulate Matter (Gravimetric)	Daily mean > 50 µgm^{-3}	0	0
PM_{10} Particulate Matter (Gravimetric)	Annual mean > 40 µgm^{-3}	0	-
Nitrogen Dioxide	Annual mean > 40 µgm^{-3}	0	-
Nitrogen Dioxide	Hourly mean > 200 µgm^{-3}	0	0

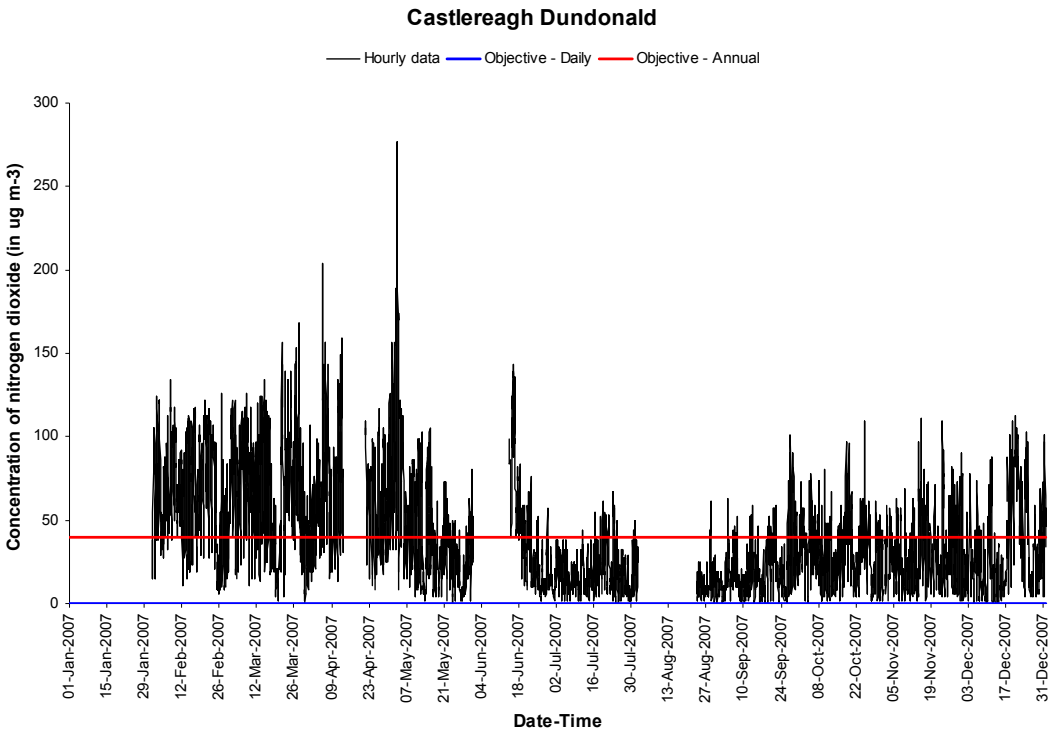
* PM_{10} Indicative Gravimetric Equivalent µg m^{-3}

\+ PM_{10} as measured by a TEOM using a factor of 1.3 for Indicative Gravimetric Equivalence

All mass units are at 20°C and 1013mb

NO_X mass units are NO_X as NO_2 µg m^{-3}

Appendix A1.2 - Automatic Measurements at Castlereagh Dundonald



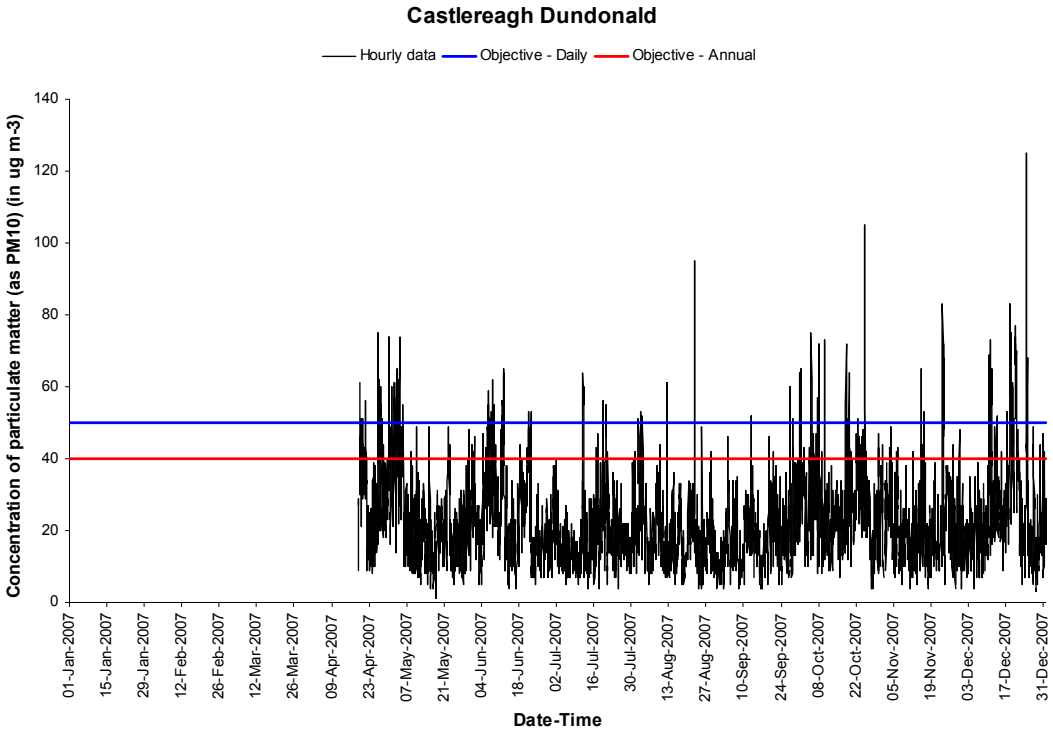
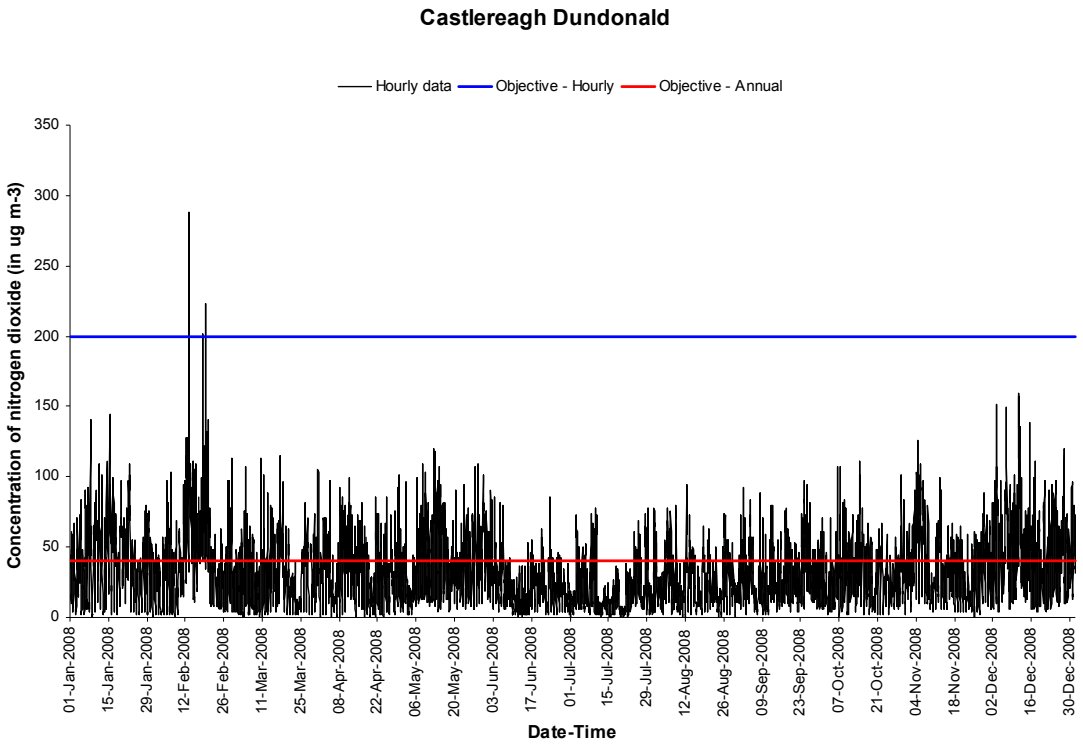


Figure A1.3: 2007 hourly measurements of nitrogen dioxide (in µg NO_2 m^{-3}, upper panel) and of particulate matter (as PM_{10} in µg m^{-3}, lower panel) for the Castlereagh Dundonald site.



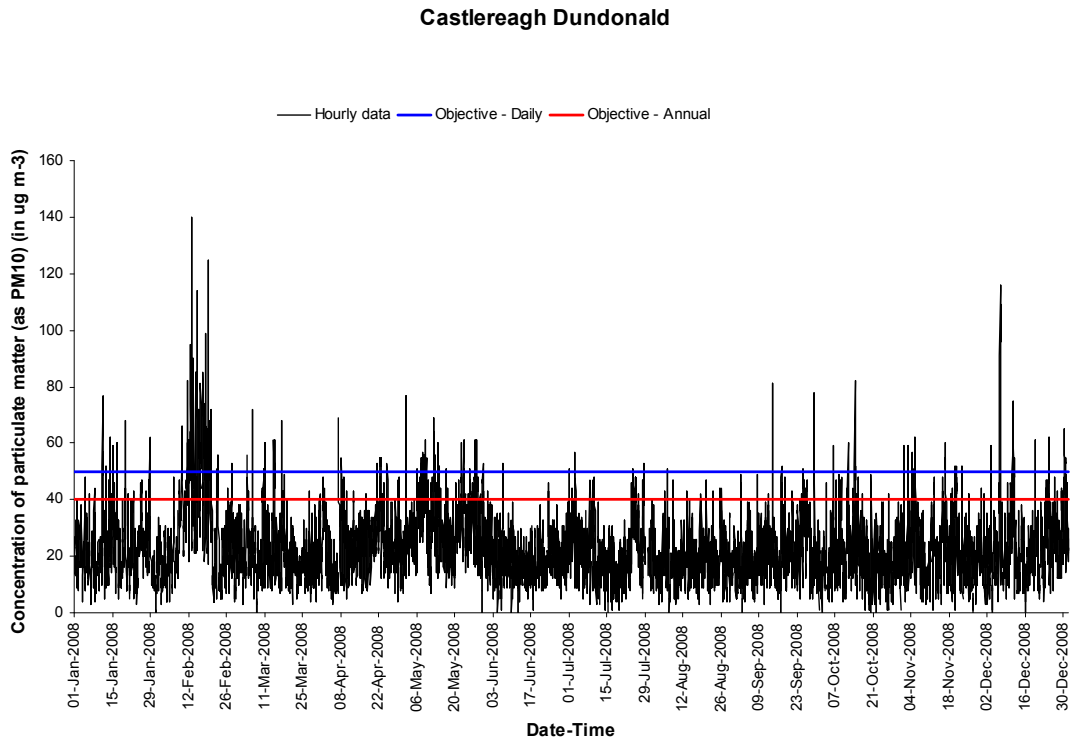


Figure A1.4: 2008 hourly measurements of nitrogen dioxide (in µg NO_2 m^{-3}, upper panel) and of particulate matter (as PM_{10} in µg m^{-3}, lower panel) for the Castlereagh Dundonald site.

Statistics: Castlereagh Dundonald

These data have been fully ratified by AEA Technology

(a) 1st January to 31st December 2007

Pollutant	PM_{10}*+	NO	NO_2	NO_X
Number Very High	0	-	0	-
Number High	0	-	0	-
Number Moderate	0	-	0	-
Number Low	6088	-	6896	-
Maximum 15-minute mean	296 µg m^{-3}	654 µg m^{-3}	319 µg m^{-3}	1144 µg m^{-3}
Maximum hourly mean	125 µg m^{-3}	579 µg m^{-3}	277 µg m^{-3}	997 µg m^{-3}
Maximum running 8-hour mean	72 µg m^{-3}	388 µg m^{-3}	174 µg m^{-3}	682 µg m^{-3}
Maximum running 24-hour mean	57 µg m^{-3}	254 µg m^{-3}	119 µg m^{-3}	467 µg m^{-3}
Maximum daily mean	54 µg m^{-3}	215 µg m^{-3}	104 µg m^{-3}	398 µg m^{-3}
Average	22 µg m^{-3}	38 µg m^{-3}	39 µg m^{-3}	97 µg m^{-3}
Data capture	69.5 %	78.7 %	78.7 %	78.7 %

Pollutant	Air Quality Regulations (Northern Ireland) 2003	Exceedences	Days
PM_{10} Particulate Matter (Gravimetric)	Daily mean > 50 µgm^{-3}	0	-
PM_{10} Particulate Matter (Gravimetric)	Annual mean > 40 µgm^{-3}	2	2
Nitrogen Dioxide	Annual mean > 40 µgm^{-3}	1	1
Nitrogen Dioxide	Hourly mean > 200 µgm^{-3}	0	-

(b) 1st January to 31st December 2008

Pollutant	PM_{10}*+	NO	NO_2	NO_X
Number Very High	0	-	0	-
Number High	0	-	0	-
Number Moderate	0	-	1	-
Number Low	8684	-	8746	-
Maximum 15-minute mean	299 µgm^{-3}	1119 µgm^{-3}	323 µgm^{-3}	2032 µgm^{-3}
Maximum hourly mean	140 µgm^{-3}	985 µgm^{-3}	288 µgm^{-3}	1793 µgm^{-3}
Maximum running 8-hour mean	95 µgm^{-3}	408 µgm^{-3}	136 µgm^{-3}	757 µgm^{-3}
Maximum running 24-hour mean	62 µgm^{-3}	264 µgm^{-3}	99 µgm^{-3}	502 µgm^{-3}
Maximum daily mean	56 µgm^{-3}	210 µgm^{-3}	94 µgm^{-3}	413 µgm^{-3}
Average	23 µgm^{-3}	33 µgm^{-3}	32 µgm^{-3}	83 µgm^{-3}
Data capture	98.1 %	99.6 %	99.6 %	99.6 %

Pollutant	Air Quality Regulations (Northern Ireland) 2003	Exceedences	Days
PM_{10} Particulate Matter (Gravimetric)	Daily mean > 50 µgm^{-3}	4	4
PM_{10} Particulate Matter (Gravimetric)	Annual mean > 40 µgm^{-3}	0	-
Nitrogen Dioxide	Annual mean > 40 µgm^{-3}	0	-
Nitrogen Dioxide	Hourly mean > 200 µgm^{-3}	3	3

* PM_{10} Indicative Gravimetric Equivalent µg m^{-3}

\+ PM_{10} as measured by a TEOM using a factor of 1.3 for Indicative Gravimetric Equivalence

All mass units are at 20°C and 1013mb

NO_X mass units are NO_X as NO_2 µg m^{-3}

A1.3 QA/QC and PM Adjustment

A1.3.1 QA/QC of the automatic monitoring instruments

Castlereagh Borough Council commissioned AEA Technology to provide the QA/QC of the automatic measurements of NO_2-NO_x and PM_{10} from the two sites. AEA Technology is the current QA/QC contractor for the national automatic urban and rural network (AURN) operated by the Department for Environment, Food and Rural Affairs and the Devolved Administrations. Local authority staff act as the local site operator and visit the sites on a fortnightly basis by the local site operator with six monthly audits of the site by AEA Technology.

Scaled and fully ratified datasets from the Castlereagh Dundonald and Castlereagh Lough View Drive sites have been provided for 2008, together with the associated calendar year statistical summaries (see **Appendix A1.1**).

A1.3.2 PM monitoring adjustment

TEOM measurements of PM_{10} are known to under-read with respect to the reference gravimetric method. Until recently, a default correction of 1.3 was applied to TEOM data in order to generate a nominal "gravimetric-equivalent result" [paragraph 3.34 in TG (2009)]. This factor has been used by AEA Technology to convert the Castlereagh TEOM data into gravimetric equivalents.

The latest technical guidance [TG, 2009] recommends the use of the Volatile Correction Model (VCM) developed by King's College London. The volatile correction model uses measurements of the volatile PM_{10} component made using FDMS TEOM instruments, located within 130 km of the site. As discussed in the 2009 updating and screening assessment (USA, 2009), the only operational site in 2008 was that at Lisburn Dunmurry High School (from the end of February). With the lower data capture and to ensure consistency with the previous years, the exceedence statistics presented in Section 2.2.3 were based on the scaling factor of 1.3.

A2 Diffusion tube measurements

A2.1 Measurements

The bias-adjusted diffusion tube measurements made in Castlereagh for 2007 and 2008 are shown in Table A2.1. The bias-adjustment factors used were 0.90 (for 2007) and 0.82 (for 2008), as listed in Table A2.2.

Table A2.1: Bias-adjusted diffusion tube measurements

2007

Site ID	Site	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Castlereagh 1	Cregagh Road	29.7		33.3	24.3	14.4	19.8	21.6	24.3		29.7	36.9	35.1
Castlereagh 2	Everton Drive	26.1	26.1	18.0	22.5	11.7	11.7	9.9	10.8	18.9	9.0	20.7	22.5
Castlereagh 3	Downshire Park	18.0	21.6			9.9			7.2	14.4	16.2	22.5	18.9
Castlereagh 4	Upper Newtownards Rd	47.7	62.1	54.0	27.0	38.7	47.7	34.2	38.7	51.3	48.6	69.3	60.3
Castlereagh 5	Newtownbreda Road	32.4	38.7	46.8	4.5	20.7	45.0	32.4	32.4	38.7	33.3	47.7	36.0
Castlereagh 6	Saintfield Road	11.7	24.3	18.9	15.3	9.9	20.7	12.6	9.0	17.1	19.8	16.2	27.9

2008

Site ID	Site	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Castlereagh 1	Cregagh Road	22.6	28.5	21.9	23.4	19.0	18.3	13.9	20.4	15.3	23.4	32.1	39.4
Castlereagh 2	Everton Drive	18.3	21.2	14.6	9.5	11.7	8.0	6.6	9.5		13.9	17.5	25.6
Castlereagh 3	Downshire Park	17.5	15.3										
Castlereagh 4	Upper Newtownards Rd	50.4	54.0								57.4	52.6	74.2
Castlereagh 5	Newtownbreda Road	31.4	27.0	31.4	36.5	42.3	27.0	24.1	27.0	31.4	24.1	38.7	38.0
Castlereagh 6	Saintfield Road	12.4	16.8	9.5	15.3	18.3	10.2	10.2	11.7	29.9	8.8	16.1	19.0

A2.2 Bias adjustment of the diffusion tubes

Up to November 2004, the NO_2 diffusion tubes were supplied and analysed by Ruddock and Sheratt. Since then, Casella has supplied and analysed the tubes. The tubes are currently prepared using 10% TEA in water.

The bias adjustment factors used to adjust the diffusion tube measurements are summarised in Table A.2.4. The factor of 1.374 was derived from a co location study at the North Down Borough Council automatic site in 2003/2004. In the absence of any other appropriate figure, this factor was applied to the diffusion tube results between January 2001 and October 2004.

Since November 2004, the bias adjustment factors have been taken from the bias-adjustment spreadsheet available on the LAQM page of the National Air Quality website for the method used to prepare the diffusion tube and the analytical laboratory used. These include the Castlereagh measurements for 2007 and 2008. Sets of three diffusion tubes were exposed at the automatic monitoring sites in 2007 (Casltereagh Lough View Drive) and 2008 (Casltereagh Lough View Drive and Dundonald).

Table A2.2: Bias adjustment factors used to correct the Castlereagh NO_2 diffusion tube measurements.

Year	Bias Adjustment Factor	Comment
2001	1.374	From co-located measurements made by North Down Borough Council in 2003/2004
2002	1.374	As above
2003	1.374	As above
2004	1.374 0.83 (a)	As above. Following the change of supplier, the factor was taken as the weighted average of the 7 studies listed in the bias-adjustment spreadsheet available from the LAQM page of the National Air Quality website[5].
2005	0.80	The factor was taken as the weighted average of the 13 studies listed in the bias-adjustment spreadsheet. The 2006 USA used 0.81 as an average across the Eastern group.
2006	0.87	The factor was taken as the weighted average of the 10 studies listed in the bias-adjustment spreadsheet. The Lisburn and North Down measurements were included in the weighted average.
2007	0.90	The factor was taken as the weighted average of the 17 studies listed in the bias-adjustment spreadsheet. The Castlereagh site-specific value was 1.07 and this was included in the weighted average.
2008	0.82	The factor was taken as the weighted average of the 9 studies included in bias-adjustment spreadsheet. The Castlereagh site-specific values were 0.65 and 0.73 and these were included in the weighted average.

Note (a) There was a change in the supplier and the analysis of the diffusion tube in November 2004.

[5] See http://www.airquality.co.uk/archive/laqm/tools.php

Appendix B: Modelling Data and Results

The input data for, verification and contour plots from the dispersion modeling:

Table B.1: Information on the road links and the assumptions made on road widths, canyon heights and road speeds

Table B.2: Traffic flows (AADTs) and vehicle composition recorded by Northern Ireland Department for Regional Development for 2007

Table B.3: Growth factors (central forecast) for the different vehicle types generated by the Automated Traffic Growth calculator for Scotland, Wales and Northern Ireland

Table B.4: Time series of actual and projected traffic flows for 1998-2010

Table B.5: Diurnal emission factors for road vehicle NO_x emissions, as used for the UK in the EMEP UNIOZONE open-source model

Table B.6: Breakdown of Traffic Flows on the A20 Upper Newtownards Road to hour of day for 2007, 2008 and 2010, as derived from the reported 5-day AADT for 2007 for the reported vehicle composition

Table B.7: Verification of the Dispersion Modelling (3% HGV)

Table B.8: Verification of the Dispersion Modelling (8% HGV)

Table B.9: Adjusted roadside and total annual mean NO_x and PM_{10} concentrations as calculated using ADMS-Roads for selected receptor locations in Dundonald for 2007 and 2010 and the derived annual mean NO_2 concentrations

Figure B.1 Contour plots of the modelled annual mean NO_2 concentration (in $\mu g\ m^{-3}$) for 2007 (upper panel) and 2010 (lower panel).

Table B.1a: Spatial parameters, road widths, canyon heights and speeds as a function of day used for the modelled east-bound road links.

Link	Easting	Northing	Elevation (in m)	Road Width (in m)	Canyon Height (in m)	Speed (in kph) 07:00-09:00	Speed (in kph) 15:00-18:00	Speed (in kph) 09:00-15:00	Speed (in kph) 18:00-07:00
A20_East_1	341518 341640 341707	374067 374068 374066	0	10	0	40	25	40	40
A20_East_2	341707 341766 341794 341894	374066 374062 374058 374037	0	6	0	40	25	40	40
A20_East_3	341894 341930 341965 341971	374037 374028 374023 374024	0	20	10	15	15	20	20
A20_East_4	341971 341992	374024 374027	0	18	15	10	10	15	15
A20_East_5	341992 342093 342110 342170 342300 342345 342351	374027 374055 374058 374061 374064 374068 374071	0	6	0	40	25	40	40
A20_East_6	342351 342419 342457 342549	374071 374078 374084 374103	0	10	0	40	55	55	55

Table B.1b: Spatial parameters, road widths, canyon heights and speeds as a function of day used for the modelled west-bound road links.

Link	Easting	Northing	Elevation (in m)	Road Width (in m)	Canyon Height (in m)	Speed (in kph) 07:00-09:00	Speed (in kph) 15:00-18:00	Speed (in kph) 09:00-15:00	Speed (in kph) 18:00-07:00
A20_West_1	341518 341640 341707	374053 374053 374055	0	10	0	30	30	40	40
A20_West_2	341707 341764 341793 341839 341890	374055 374054 374050 374043 374031	0	6	0	25	25	40	40
A20_West_3a	341890 341949 341971	374031 374017 374017	0	20	10	20	20	20	20
A20_West_3b	341971 341996 342017	374017 374021 374027	0	18	15	10	10	15	15
A20_West_4	342017 342095 342118 342150 342284 342348	374027 374049 374052 374055 374057 374058	0	6	0	20	20	30	30
A20_West_5	342348 342417 342552	374058 374064 374090	0	10	0	40	40	55	55

Table B.2: Recorded annual average daily traffic (AADT) counts for 2007 and composition (as percentage) of the traffic by vehicle type [taken from DRDNI, 2008].

CP #	Route	Location	Easting	Northing	AADT	Car	LGV	HGV-Rigid	HGV-Artic	Bus/Coach
216	**A20**	**East Upper Newtownards Road Belfast (at Quarry Inn)**	**343728**	**374032**	**23,820**	**92.3**	**4.4**	**2.0**	**0.8**	**0.5**
217	A22	East Comber Road Belfast (south east of New Line)	342520	372789	11,300	96.4	1.3	1.6	0.7	0.0
218	A23	East Ballygowan Road Belfast (at Roselawn)	338808	370247	13,150	91.9	4.4	2.8	0.7	0.2
219	A24	East Belfast Carryduff (at Baronscourt)	336752	365930	30,570	86.8	7.3	3.3	1.2	1.4
220	A55	East Shaws Bridge Belfast	332258	369408	31,650	93.5	3.3	2.4	0.8	0.1
221	A55	East Upper Knockbreda Road Belfast	335838	370822	39,210	93.0	2.5	3.9	0.5	0.0
222	A55	East Parkway Belfast	338583	374764	22,620	91.0	4.4	3.0	1.3	0.3

Table B.3: Central forecast growth factors for different vehicles for a 2007 base year as generated by the Automated Traffic Growth calculator for Scotland, Wales and Northern Ireland.

Year	Cars	LGV	HGV-Rigid	HGV-Artic	PSV	All Traffic
2007	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
2008	1.0168	1.0268	1.0078	1.0252	1.0059	1.0168
2009	1.0336	1.0518	1.0155	1.0522	1.0137	1.0354
2010	1.0504	1.0768	1.0233	1.0791	1.0215	1.0541

Table B.4: Recorded annual average daily traffic (AADT) counts for the years 1998-2007 and projected counts for 2008-2010 for traffic census points in the Castlereagh Borough and surrounding area.

CP #	Route	Location	Easting	Northing	AADT (7-day) in vehicles per day)												
					1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
216	**A20**	**East Upper Newtownards Road Belfast (at Quarry Inn)**	**343728**	**374032**	**24,780**	**24,710**	**24,510**	**25,010**	**25,390**	**24,890**	**24,270**	**23,080**	**24,220**	**23,820**	**24,226**	**24,632**	**25,037**
217	A22	East Comber Road Belfast (south east of New Line)	342520	372789	9,360	9,600	-	10,285	10,320	10,440	10,770	10,860	11,050	11,300	11,490	11,680	11,870
218	A23	East Ballygowan Road Belfast (at Roselawn)	338808	370247	10,710	10,720	11,130	10,620	11,680	12,080	12,180	12,370	12,240	13,150	13,374	13,597	13,820
219	A24	East Belfast Carryduff (at Baronscourt)	336752	365930	28,190	30,000	-	-	30,890	29,140	30,260	30,080	30,220	30,570	31,095	31,617	32,140
220	A55	East Shaws Bridge Belfast	332258	369408	29,460	28,960	-	25,560	30,210	32,470	32,110	31,750	31,040	31,650	32,187	32,722	33,258
221	A55	East Upper Knockbreda Road Belfast	335838	370822	37,020	37,940	-	40,130	37,660	37,240	39,390	38,250	39,270	39,210	39,866	40,521	41,175
222	A55	East Parkway Belfast	338583	374764	18,980	19,410	20,240	20,650	21,610	21,430	20,570	23,020	23,030	22,620	23,005	23,390	23,774

Notes (a) Recorded AADTs taken from Traffic and travel information 2007 incorporating annual traffic census and vehicle kilometres of travel (DRDNI, 2008); (b) AADTs for 2008-2010 were calculated from the 2007 AADTs and traffic composition using the growth factors for the different vehicle types provided in Table B.3.

Table B.5: Diurnal emission factors for road vehicle NO_x emissions, as used for the UK in the EMEP UNIOZONE open-source model.

Hour	Factor	Comment
00:00-01:00	0.206	
01:00-02:00	0.151	
02:00-03:00	0.128	
03:00-04:00	0.112	
04:00-05:00	0.162	
05:00-06:00	0.334	
06:00-07:00	0.687	
07:00-08:00	1.301	Not used here as actual counts available
08:00-09:00	1.582	Not used here as actual counts available
09:00-10:00	1.442	
10:00-11:00	1.500	
11:00-12:00	1.535	

Hour	Factor	Comment
12:00-13:00	1.488	
13:00-14:00	1.432	
14:00-15:00	1.468	
15:00-16:00	1.495	Not used here as actual counts available
16:00-17:00	1.614	Not used here as actual counts available
17:00-18:00	1.752	Not used here as actual counts available
18:00-19:00	1.514	
19:00-20:00	1.209	
20:00-21:00	0.954	
21:00-22:00	0.784	
22:00-23:00	0.634	
23:00-24:00	0.519	

Table B.6a - Breakdown of Traffic Flows on the A20 Upper Newtownards Road to hour of day for 2007, 2008 and 2010, as derived from the reported 5-day AADT for 2007 for the reported vehicle composition.

Start Hour of Day	2007				2008				2010			
	# of LGV West-bound Channel	# of HGV West-bound Channel	# of LGV East-bound Channel	# of HGV East-bound Channel	# of LGV West-bound Channel	# of HGV West-bound Channel	# of LGV East-bound Channel	# of HGV East-bound Channel	# of LGV West-bound Channel	# of HGV West-bound Channel	# of LGV East-bound Channel	# of HGV East-bound Channel
0	255	8	237	8	260	8	241	8	269	8	249	8
1	255	8	237	8	260	8	241	8	269	8	249	8
2	255	8	237	8	260	8	241	8	269	8	249	8
3	255	8	237	8	260	8	241	8	269	8	249	8
4	255	8	237	8	260	8	241	8	269	8	249	8
5	255	8	237	8	260	8	241	8	269	8	249	8
6	255	8	237	8	260	8	241	8	269	8	249	8
7	1509	51	658	22	1535	52	669	23	1587	53	692	23
8	1509	51	658	22	1535	52	669	23	1587	53	692	23
9	664	23	615	21	675	23	626	21	698	23	647	22
10	664	23	615	21	675	23	626	21	698	23	647	22
11	664	23	615	21	675	23	626	21	698	23	647	22
12	664	23	615	21	675	23	626	21	698	23	647	22
13	664	23	615	21	675	23	626	21	698	23	647	22
14	664	23	615	21	675	23	626	21	698	23	647	22
15	803	27	1373	47	816	28	1397	47	844	28	1444	49
16	803	27	1373	47	816	28	1397	47	844	28	1444	49
17	803	27	1373	47	816	28	1397	47	844	28	1444	49
18	255	8	237	8	260	8	241	8	269	8	249	8
19	255	8	237	8	260	8	241	8	269	8	249	8
20	255	8	237	8	260	8	241	8	269	8	249	8
21	255	8	237	8	260	8	241	8	269	8	249	8
22	255	8	237	8	260	8	241	8	269	8	249	8
23	255	8	237	8	260	8	241	8	269	8	249	8
Total	12726	425	12206	415	12948	430	12418	417	13391	432	12835	429
Total	**25772**				**26213**				**27087**			

Table B.6b - Breakdown of Traffic Flows on the A20 Upper Newtownards Road to hour of day for 2007, 2008 and 2010, as derived from the reported 5-day AADT for 2007 with HGVs representing 8% of the Traffic Flow.

Start Hour of Day	2007				2008				2010			
	# of LGV West-bound Channel	# of HGV West-bound Channel	# of LGV East-bound Channel	# of HGV East-bound Channel	# of LGV West-bound Channel	# of HGV West-bound Channel	# of LGV East-bound Channel	# of HGV East-bound Channel	# of LGV West-bound Channel	# of HGV West-bound Channel	# of LGV East-bound Channel	# of HGV East-bound Channel
0	243	20	225	20	247	20	229	20	255	21	237	21
1	243	20	225	20	247	20	229	20	255	21	237	21
2	243	20	225	20	247	20	229	20	255	21	237	21
3	243	20	225	20	247	20	229	20	255	21	237	21
4	243	20	225	20	247	20	229	20	255	21	237	21
5	243	20	225	20	247	20	229	20	255	21	237	21
6	243	20	225	20	247	20	229	20	255	21	237	21
7	1435	125	626	54	1460	127	637	55	1509	131	658	57
8	1435	125	626	54	1460	127	637	55	1509	131	658	57
9	631	55	585	51	642	56	595	52	663	58	615	53
10	631	55	585	51	642	56	595	52	663	58	615	53
11	631	55	585	51	642	56	595	52	663	58	615	53
12	631	55	585	51	642	56	595	52	663	58	615	53
13	631	55	585	51	642	56	595	52	663	58	615	53
14	631	55	585	51	642	56	595	52	663	58	615	53
15	764	66	1306	114	776	68	1328	116	802	70	1374	119
16	764	66	1306	114	776	68	1328	116	802	70	1374	119
17	764	66	1306	114	776	68	1328	116	802	70	1374	119
18	243	20	225	20	247	20	229	20	255	21	237	21
19	243	20	225	20	247	20	229	20	255	21	237	21
20	243	20	225	20	247	20	229	20	255	21	237	21
21	243	20	225	20	247	20	229	20	255	21	237	21
22	243	20	225	20	247	20	229	20	255	21	237	21
23	243	20	225	20	247	20	229	20	255	21	237	21
Total	12107	1038	11605	1016	12311	1054	11805	1030	12717	1093	12209	1062
Total	**25766**				**26200**				**27081**			

Model Verification and Scaling

The predicted results from a dispersion model may differ from measured concentrations for various reasons [TG, 2009]:

- model limitations and uncertainties in model input parameters such as roughness length, minimum Monin-Obukhov parameters;
- uncertainties in source activity data such as traffic flows, stack emissions and emissions factors;
- uncertainties in the meteorological data;
- use of estimates of background concentrations;
- uncertainties associated with monitoring data, including locations.

There are additional factors to consider when modelling dispersion in a street canyon, for example:

- the orientation of the street with respect to wind direction;
- wind speed;
- the height of buildings on either side of the street;
- the variation in the height of the buildings;
- the volume and speed of traffic on the roads;
- the distance from the roadside to the buildings;
- whether there are any gaps in buildings or roads junctions along sections of the street; and
- other atmospheric conditions such as temperature.

All of these physical parameters affect the pattern of dispersion within a street canyon such that very complicated wind flows and vortexes may form under certain conditions making it very difficult to fully understand and to predict accurately the concentrations at specific locations.

Model verification is the process by which these and other uncertainties are investigated and where possible minimised. In reality, the differences between modelled and monitored results are likely to be a combination of all of these aspects. The technical guidance acknowledges that an adjustment of modelled results may be required in order ensure that the final concentrations presented are representative of monitoring information from an area.

The model verification and adjustment undertaken in this study are presented in Tables B.6 and B.7 for the two vehicle compositions, designated (a) 3% HGV and (b) 8% HGV. The verification and adjustment follows the latest technical guidance [TG, 2008]. The adjustment factors are comparable to those cited in the examples in the technical guidance [TG, 2009] and in other similar detailed assessments (such as for Mid Befordshire District Council [MB, 2008]).

Table B.7a: Verification of the Dispersion Modelling for NO_2 and PM_{10} (3% HGV)

Site	Year	Annual Mean NO_x Concentration (in μg m^{-3} as NO_2)							Annual Mean NO_2 Concentration (in μg m^{-3})			
		Measured	Background	Measured Road Contribution (Note 1)	Unadjusted Modelled Road Contribution	Scale Factor	Adjusted Modelled Road Contribution (Note 2)	Adjusted Modelled Total (Note 3)	Background (Note 4)	Derived Road (Note 4)	Derived Total (Note 5)	Measured
Automatic Monitoring Site	2007	38.0	97.3	13.6	83.7	15.5	5.41	69.5	83.1	9.0	26.0	35.0
	2008	32.0	83.0	12.9	70.1	15.1	4.63	67.9	80.8	8.9	25.4	34.3
Diffusion Tube site	2007	48.0	140.4	12.5	127.9	38.2	3.35	171.6	184.1	9.0	46.8	55.7
	2008	55.0	179.9	11.9	168.0	36.8	4.57	165.0	176.9	8.3	47.1	55.4
						Average	4.49					

[1] Road NOx = Total NOx – Background NOx
[2] Adjusted road NOx = Road NOx x average verification factor
[3] Adjusted Total NOx = Adjusted road NOx + Background NOx
[4] Background and Adusted Road NO_2 = from NOx to NO_2 calculator (available LAQM Tools)
[5] Adjusted Total NO_2 = Adjusted road NO_2 + Background NO_2

Table B.7b: Verification of the Dispersion Modelling for PM_{10} (3% HGV)

Site	Year	Annual Mean PM_{10} Concentration (in μg m^{-3})						
		Measured	Background	Measured Road Contribution (Note 1)	Unadjusted Modelled Road Contribution	Scale Factor	Adjusted Modelled Road Contribution	Adjusted Modelled Total (Note 3)
Automatic Monitoring Site	2007	22.1	17.6	4.5	0.6	7.18	5.0	22.7
	2008	22.8	17.5	5.4	0.6	8.99	4.8	22.3
					Average	8.08		

[1] PM_{10} (Road) = PM_{10} (Total) –PM_{10} (Background)
[2] PM_{10} (Adjusted Road) = PM_{10} (Road) x average verification factor
[3] PM_{10} (Adjusted Total) = PM_{10} (Adjusted Road) + PM_{10} (Background)

Table B.8a: Verification of the Dispersion Modelling for NO_2 and PM_{10} (8% HGV)

Site	Year	Annual Mean NO_x Concentration (in μg m^{-3} as NO_2)							Annual Mean NO_2 Concentration (in μg m^{-3})			
		Measured	Background	Measured Road Contribution (Note 1)	Unadjusted Modelled Road Contribution	Scale Factor	Adjusted Modelled Road Contribution (Note 2)	Adjusted Modelled Total (Note 3)	Background (Note 4)	Derived Road (Note 4)	Derived Total (Note 5)	Measured
Automatic Monitoring Site	2007	97.3	13.6	83.7	24.2	3.46	68.0	81.6	9.2	25.6	34.8	38.0
	2008	83.0	12.9	70.1	23.7	2.96	66.6	79.5	8.8	25.4	34.2	32.0
Diffusion Tube site	2007	140.4	12.5	127.9	62.7	2.04	176.1	188.6	8.7	47.7	56.4	48.0
	2008	179.9	11.9	168.0	60.5	2.78	169.8	181.7	8.3	47.1	55.4	55.0
					Average =	2.81						

[1] Road NOx = Total NOx – Background NOx
[2] Adjusted road NOx = Road NOx x average verification factor
[3] Adjusted Total NOx = Adjusted road NOx + Background NOx
[4] Background and Adusted Road NO_2 = from NOx to NO_2 calculator (available LAQM Tools)
[5] Adjusted Total NO_2 = Adjusted road NO_2 + Background NO_2

Table B.8b: Verification of the Dispersion Modelling for PM_{10} (8% HGV)

Site	Year	Annual Mean PM_{10} Concentration (in μg m^{-3})						
		Measured	Background	Measured Road Contribution (Note 1)	Unadjusted Modelled Road Contribution	Scale Factor	Adjusted Modelled Road Contribution	Adjusted Modelled Total (Note 3)
Automatic Monitoring Site	2007	22.1	17.6	4.5	0.8	5.35	5.1	22.7
	2008	22.8	17.5	5.4	0.8	6.80	4.8	22.2
						6.07		

[1] PM_{10} (Road) = PM_{10} (Total) –PM_{10} (Background)
[2] PM_{10} (Adjusted Road) = PM_{10} (Road) x average verification factor
[3] PM_{10} (Adjusted Total) = PM_{10} (Adjusted Road) + PM_{10} (Background)

Table B.9: Adjusted roadside and total annual mean NO_x and PM_{10} concentrations as calculated using ADMS-Roads for selected receptor locations in Dundonald for 2007 and 2010 and the derived annual mean NO_2 concentrations.

2007	Annual Mean NO_x Concentration (in µg m^{-3} as NO_2)			Annual Mean NO_2 Concentration (in µg m^{-3})			Annual Mean PM_{10} Concentration (in µg m^{-3})		
Receptor	**Total**	**Road**	**Background**	**Total**	**Road**	**Background**	**Total**	**Road**	**Background**
R01	27.9	14.8	13.1	15.8	6.8	9.0	18.8	1.1	17.7
R02	30.2	17.1	13.1	16.8	7.8	9.0	19.0	1.3	17.7
R03	32.3	19.2	13.1	17.7	8.7	9.0	19.2	1.5	17.7
R04	36.2	23.1	13.1	19.3	10.3	9.0	19.5	1.8	17.7
R05	**172.1**	**159.0**	**13.1**	**53.7**	**44.7**	**9.0**	30.6	12.9	17.7
R06	69.0	55.9	13.1	31.0	22.0	9.0	21.9	4.2	17.7
R07	58.9	45.8	13.1	27.8	18.8	9.0	21.1	3.4	17.7
R08	55.2	42.1	13.1	26.5	17.5	9.0	20.8	3.1	17.7
R09	57.1	44.0	13.1	27.1	18.2	9.0	21.0	3.3	17.7
R10	56.1	43.0	13.1	26.8	17.8	9.0	20.9	3.2	17.7
R11	56.5	43.4	13.1	26.9	18.0	9.0	20.9	3.2	17.7
R12	58.7	45.6	13.1	27.7	18.7	9.0	21.3	3.6	17.7
R13	84.3	71.2	13.1	35.5	26.5	9.0	23.3	5.6	17.7
R14	81.2	68.1	13.1	34.6	25.6	9.0	23.1	5.4	17.7
R15	76.5	63.4	13.1	33.3	24.3	9.0	22.6	4.9	17.7
R16	59.8	46.7	13.1	28.1	19.1	9.0	21.2	3.5	17.7

2010	Annual Mean NO_x Concentration (in µg m^{-3} as NO_2)			Annual Mean NO_2 Concentration (in µg m^{-3})			Annual Mean PM_{10} Concentration (in µg m^{-3})		
Receptor	**Total**	**Road**	**Background**	**Total**	**Road**	**Background**	**Total**	**Road**	**Background**
R01	24.2	12.9	11.3	13.9	6.1	7.8	18.0	0.9	17.1
R02	26.1	14.8	11.3	14.7	6.9	7.8	18.2	1.1	17.1
R03	27.9	16.6	11.3	15.5	7.7	7.8	18.3	1.2	17.1
R04	31.2	19.9	11.3	16.9	9.1	7.8	18.5	1.4	17.1
R05	**144.9**	**133.6**	**11.3**	**49.2**	**41.4**	**7.8**	27.0	9.9	17.1
R06	58.3	47.0	11.3	27.3	19.5	7.8	20.4	3.3	17.1
R07	50.0	38.7	11.3	24.4	16.6	7.8	19.8	2.7	17.1
R08	47.0	35.7	11.3	23.3	15.5	7.8	19.6	2.5	17.1
R09	48.6	37.3	11.3	23.9	16.1	7.8	19.7	2.6	17.1
R10	47.7	36.4	11.3	23.6	15.8	7.8	19.6	2.5	17.1
R11	48.2	36.9	11.3	23.7	15.9	7.8	19.7	2.6	17.1
R12	50.2	38.9	11.3	24.5	16.7	7.8	19.9	2.8	17.1
R13	71.6	60.3	11.3	31.7	23.9	7.8	21.5	4.4	17.1
R14	69.0	57.7	11.3	30.9	23.1	7.8	21.3	4.2	17.1
R15	65.4	54.1	11.3	29.7	21.9	7.8	21.0	3.9	17.1
R16	51.6	40.3	11.3	25.0	17.2	7.8	19.9	2.8	17.1

(a) 2007

(b) 2010

Figure B.1: Contour plots of the modelled annual mean NO_2 concentration (in µg m^{-3}) for 2007 (upper panel) and 2010 (lower panel).