

In fulfilment of Part IV of the Environment Act 1995  
Local Air Quality Management

# Detailed assessment 2012



**NORWICH**  
City Council

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Prepared by	Ben Warren (Project Manager)	Ben Warren (Project Manager)		
Signature				
Approved by	Mark Chapman (Technical Director)	Mark Chapman (Technical Director)		
Signature				
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Bureau Veritas UK Limited  
 Brandon House  
 180 Borough High Street  
 SE1 1LB

Telephone: +44 (0) 207 6610 0700  
 Fax: +44 (0) 207 6610 0741  
 Registered in England 1758622  
 www.bureauveritas.co.uk

Registered Office  
 Brandon House  
 180 Borough High Street  
 SE1 1LB

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## Executive Summary

Part IV of the Environment Act 1995 places a statutory duty on local authorities to review and assess the air quality within their area and take account of Government guidance when undertaking such work.

Bureau Veritas has been commissioned by Norwich City Council to provide a Detailed Assessment investigating exceedences of the short-term objective for Nitrogen Dioxide (NO<sub>2</sub>) in Castle Meadow, Norwich. This assessment was required as more than 18 exceedences of the 1-hour mean NO<sub>2</sub> air quality objective of 200 µg/m<sup>3</sup> were recorded at this monitoring site in 2011.

Analysis of the monitoring data shows that the overwhelming majority of hourly exceedences of 200 µg/m<sup>3</sup> that have occurred over the last six years occurred over the winter of 2010/2011 up to the end of April 2011. Provisional data shows that only two exceedences have been recorded in 2012 to date, therefore it appears unlikely that the objective will be exceeded in 2012.

This indicates that there may have been a short-term set of circumstances over this period causing exceedences. If these circumstances are not repeated, then it is highly unlikely that the 1-hour mean NO<sub>2</sub> objective will be exceeded at Castle Meadow. It has been indicated that highways improvement work on Castle Meadow during this period may have involved the use of construction plant which may have had combustion emissions, contributing to the exceedences.

This leads to the conclusion that an AQMA for the 1-hour mean NO<sub>2</sub> objective is not required, as the objective was only exceeded as a result of short-term circumstances that are unlikely to be repeated. This will be confirmed in the 2013 Progress Report, when fully ratified 2012 monitoring data is available.

## 1 Introduction

### 1.1 Project Background

Part IV of the Environment Act 1995 places a statutory duty on local authorities to review and assess the air quality within their area and take account of Government Guidance when undertaking such work.

Norwich City Council (NCC) have commissioned this Detailed Assessment as the 1-hour mean objective for Nitrogen Dioxide (NO<sub>2</sub>) (200 µg/m<sup>3</sup>, not to be exceeded more than 18 times a year) was exceeded in 2011 at the automatic air quality monitoring station on Castle Meadow, Norwich.

Traffic within Castle Meadow is limited to buses, taxis, delivery vehicles and emergency service vehicles. The street is an important bus route for access to Norwich City Centre. Castle Meadow is also a Low Emission Zone (LEZ). Since 2008, only buses and coaches that meet Euro III emission standards have been allowed entry to the LEZ. In addition, a traffic regulation order stating that all vehicles waiting in Castle Meadow must switch their engines off except when passengers are boarding or exiting buses has been implemented.

### 1.2 Legislative Background

The air quality objectives applicable to Local Air Quality Management (LAQM) in England are set out in the Air Quality (England) Regulations 2000 (SI 928), The Air Quality (England) (Amendment) Regulations 2002 (SI 3043), and are shown in Table 1. This table shows the objectives in units of microgrammes per cubic metre µg/m<sup>3</sup> (milligrammes per cubic metre, mg/m<sup>3</sup> for carbon monoxide) with the number of exceedences in each year that are permitted (where applicable).

The locations where the 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 objective. Typically these include residential properties and schools/care homes for longer period (i.e. annual mean) pollutant objectives and high streets for short-term (i.e. 1-hour) pollutant objectives.

**Table 1 - Air Quality Objectives included in the Regulations for Local Air Quality Management in England**

Pollutant	Objective		Date to be Achieved By
	Concentration	Measured As	
Benzene	16.25 µg/m <sup>3</sup>	Running annual mean	31.12.2003
	3.25 µg/m <sup>3</sup>	Running annual mean	31.12.2010
1,3-Butadiene	2.25 µg/m <sup>3</sup>	Running annual mean	31.12.2003
Carbon Monoxide (CO)	10.0 mg/m <sup>3</sup>	Running 8-hour mean	31.12.2003
Lead (Pb)	0.5 µg/m <sup>3</sup>	Annual mean	31.12.2004
	0.25 µg/m <sup>3</sup>	Annual mean	31.12.2008
Nitrogen Dioxide (NO <sub>2</sub> )	200 µg/m <sup>3</sup> , not to be exceeded more than 18 times a year	1-hour mean	31.12.2005
	40 µg/m <sup>3</sup>	Annual mean	31.12.2005
Particles (PM <sub>10</sub> ) (gravimetric)	50 µg/m <sup>3</sup> , not to be exceeded more than 35 times a year	24-hour mean	31.12.2004
	40 µg/m <sup>3</sup>	Annual mean	31.12.2004
Sulphur Dioxide (SO <sub>2</sub> )	350 µg/m <sup>3</sup> , not to be exceeded more than 24 times a year	1-hour mean	31.12.2004
	125 µg/m <sup>3</sup> , not to be exceeded more than 3 times a year	24-hour mean	31.12.2004
	266 µg/m <sup>3</sup> , not to be exceeded more than 35 times a year	15-minute mean	31.12.2005

### 1.3 Local Air Quality Management (LAQM) Review and Assessment

As established by the Environment Act 1995 Part IV, all local authorities in the UK are under a statutory duty to undertake an air quality assessment within their area and determine whether they are likely to meet the air quality objectives set down by Government for a number of pollutants. The process of Review and Assessment of air quality undertaken by local authorities is set out under the Local Air Quality Management (LAQM) regime and involves a phased three yearly assessment of local air quality. Where the results of the Review and Assessment process highlight that problems in the attainment of health-based objectives for air quality will arise, the authority is required to declare an Air Quality Management Area (AQMA) – a geographic area defined by high levels of pollution and exceedences of AQS objectives.

The LAQM regime was first set down in the 1997 National Air Quality Strategy (AQS)<sup>1</sup> and introduced the idea of local authority 'Review and Assessment'. The Government subsequently published policy and technical guidance related to the Review and Assessment processes in 1998. This guidance has since been reviewed and the latest documents include Policy Guidance

<sup>1</sup> DoE, 1997, 'The United Kingdom National Air Quality Strategy', The Stationary Office

(LAQM.PG(09))<sup>2</sup> and Technical Guidance (LAQM.TG(09))<sup>3</sup>. The guidance lays down a progressive, but continuous, framework for the local authorities to carry out their statutory duties to monitor, assess and review air quality in their area and produce action plans in pursuit of the air quality objectives.

## 1.4 Summary of Review and Assessment Undertaken by Norwich City Council

The first round of review and assessment of air quality in Norwich was carried out in four stages to determine whether the AQS objectives would be met by the end of 2005. The results of these assessments indicated that there were areas of Norwich almost certain to exceed the annual mean objective for NO<sub>2</sub>. Consequently, Norwich City Council declared three AQMAs on 1st June 2003 for exceedence of the annual mean NO<sub>2</sub> objective at Grapes Hill, St. Augustines Street, and the Castle area of Norwich.

Updating and Screening Assessments (USAs) of local air quality for Norwich were produced in January 2004, March 2006 and July 2009. These reviewed the previous assessments undertaken for all pollutants identified in the AQS.

The results of a diffusion tube survey in 2007 confirmed that the annual mean objective for NO<sub>2</sub> was not met at several locations in Norwich. It was therefore decided to undertake a Detailed Assessment in 2008 to include dispersion modelling at these locations. The Detailed Assessment concluded that a further AQMA was required at Riverside. This area was declared in December 2009.

A Further Assessment of the Riverside AQMA was completed in 2010. The study confirmed the findings of the previous Detailed Assessment, namely that there were exceedences of the annual mean NO<sub>2</sub> objective to the south of Riverside Road, and that the position and extent of the AQMA was appropriate.

The 2010 Progress Report revealed exceedences of the annual mean NO<sub>2</sub> objective at King Street and Bull Close Road. The Bull Close Road exceedence was very marginal and it was decided to

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<sup>2</sup> Policy Guidance LAQM.PG(09) (2009), Part IV of the Environment Act 1995, Local Air Quality Management, Published by Defra in partnership with the Scottish Government, Welsh Assembly Government and Department of the Environment Northern Ireland, The Stationery Office

<sup>3</sup> Technical Guidance LAQM.TG(09) (2009), Part IV of the Environment Act 1995, Local Air Quality Management, Published by Defra in partnership with the Scottish Government, Welsh Assembly Government and Department of the Environment Northern Ireland, The Stationery Office

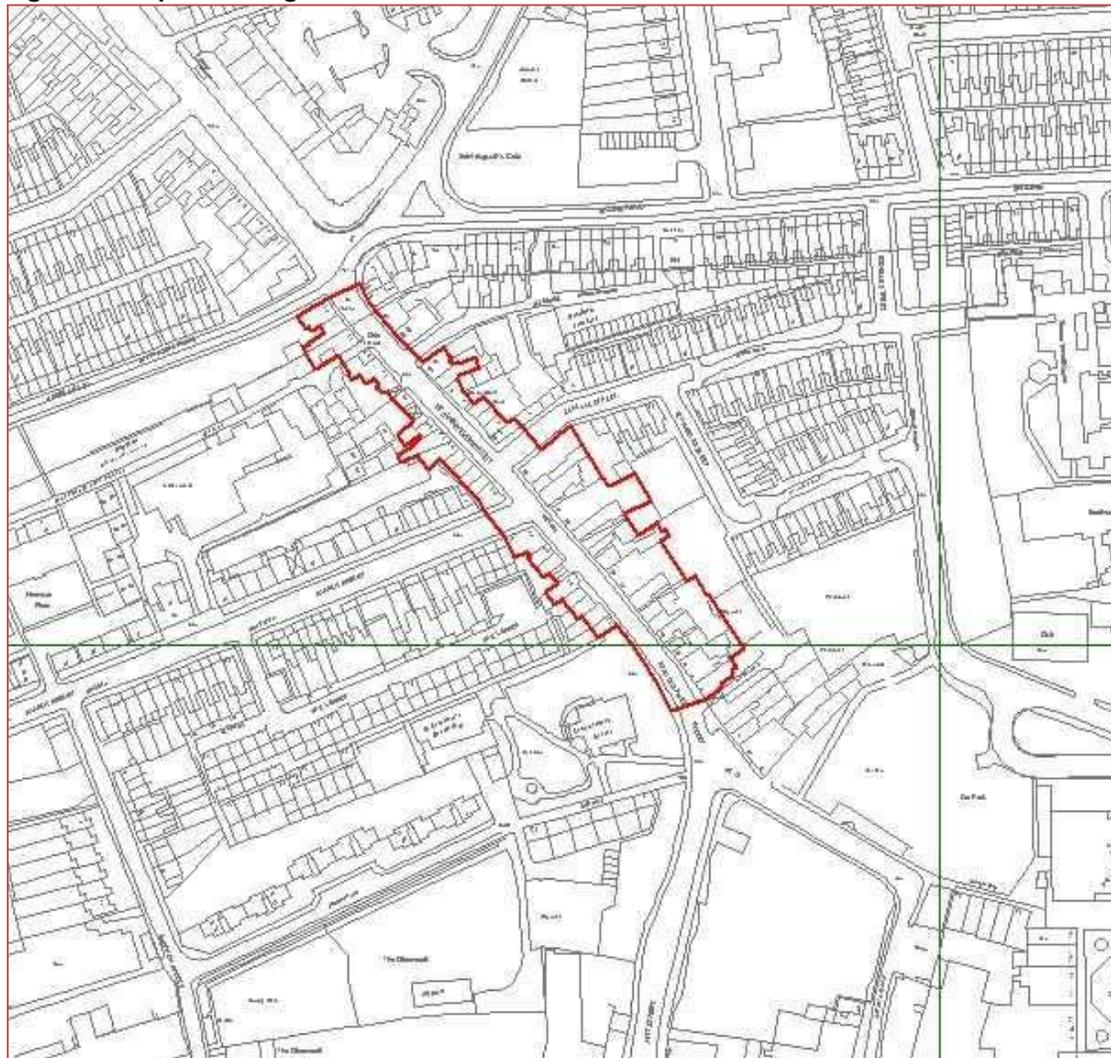
carry out a Detailed Assessment by increasing the monitoring in the area for a further year. It was stated that King Street should be declared as an AQMA.

Since the production of the 2010 Progress Report, discussion has taken place between the City Council, County Council and DEFRA. It has been agreed in principle that rather than declare King Street as a further AQMA, it would be preferable to revoke the existing four AQMAs and replace them with one larger area to encompass all of them, as shown in Figure 5.

The 2011 Progress Report concluded that the Council should move forward in declaring the whole town centre as an AQMA and to continue to monitor at locations across the city. The location and extent of the AQMAs is shown in Figure 1 to Figure 5.

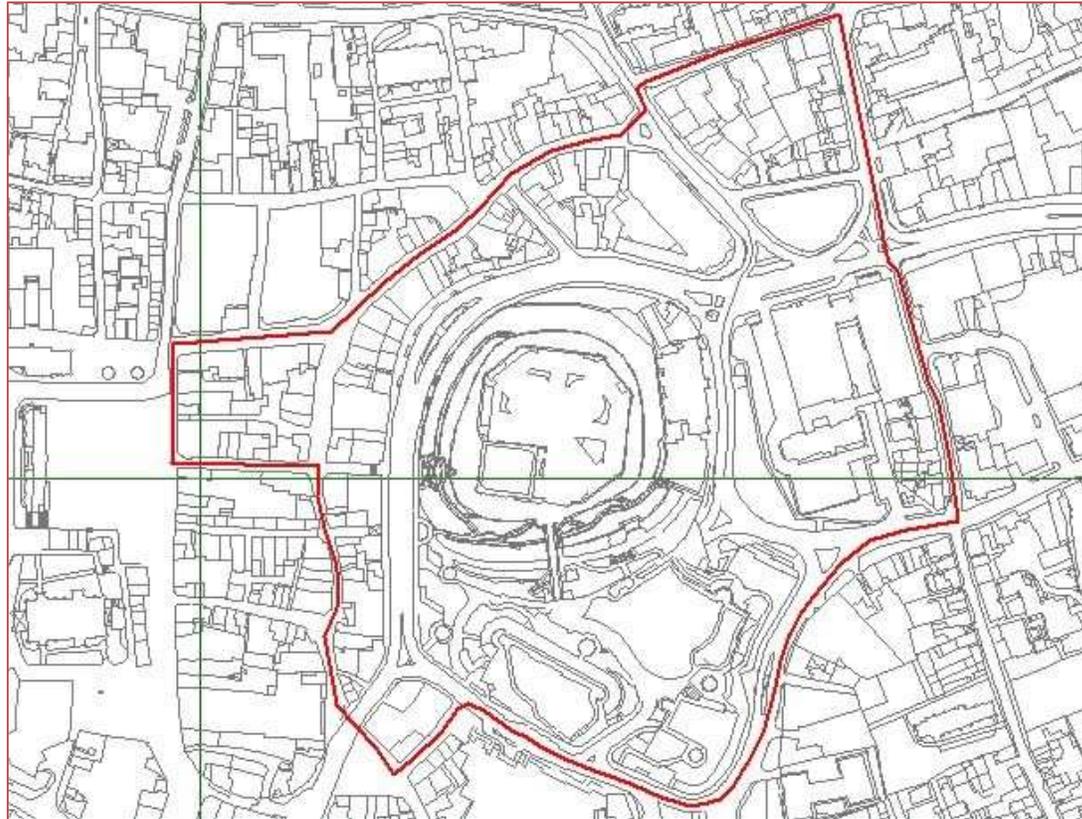
The 2012 Updating and Screening Assessment recommended that following the exceedence of the 1-hour mean objective for NO<sub>2</sub> recorded at the Castle Meadow continuous monitoring station, a Detailed Assessment of monitoring data should be carried out to understand the potential for the 1-hour mean objective for NO<sub>2</sub> to be exceeded in this area.

Figure 1 - Map of St. Augustine's AQMA



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Figure 2 - Map of Castle AQMA



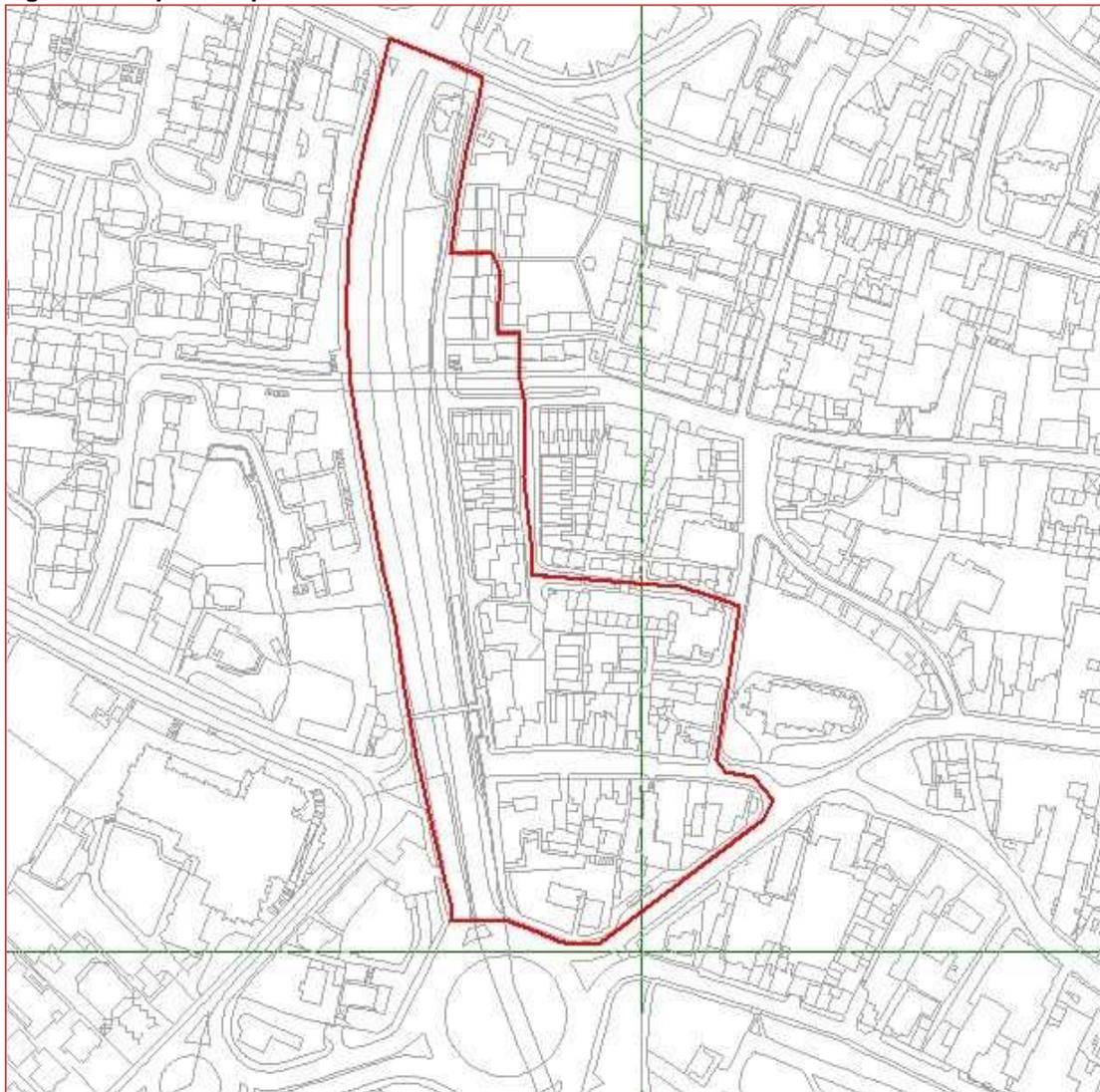
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Figure 3 - Map of Riverside AQMA



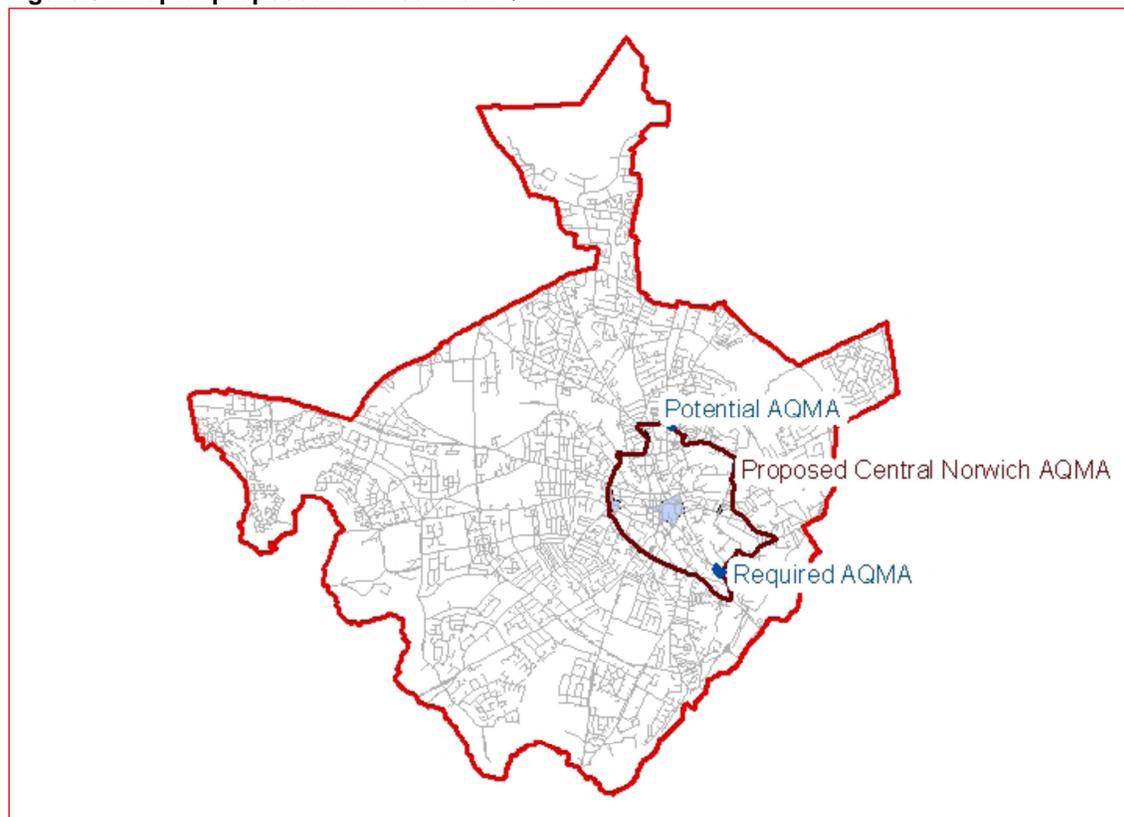
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Figure 4 - Map of Grapes Hill AQMA



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Figure 5 - Map of proposed town centre AQMA



## 1.5 Scope and Methodology of the Detailed Assessment

The purpose of the Detailed Assessment is to provide the local authority with an opportunity to supplement the information they have gathered in their earlier Review and Assessment work and more accurately assess the impact of pollution sources on local receptors at identified hotspots.

The general purpose of the Detailed Assessment is to provide robust information in order to determine if exceedences of the AQS objectives are likely to occur in the assessed areas and, if confirmed, to determine the extent of the areas of exceedence. This information would assist in establishing the area and any amendments to the existing AQMA in Norwich, if needed. This Assessment will seek to identify with reasonable certainty whether or not pollutant concentrations are likely to exceed the 1-hour mean NO<sub>2</sub> objective and, if so, define the extent and magnitude of the exceedences.

The Detailed Assessment follows the methodology and uses the tools recommended by DEFRA's Technical Guidance LAQM.TG(09) to complete such assessment. TG(09) states that "*Because of the wide range of sources and local circumstances that may prevail, it is not possible to set prescriptive guidance for the Detailed Assessment*". It is considered that a detailed analysis of the monitoring data collected in Castle Meadow and in Norwich in general is the best methodology for this Detailed Assessment. Further modelling of pollution concentrations in Castle Meadow is not considered to be beneficial in this assessment (at this time) as "*Dispersion models are inevitably poorer at predicting short-term peaks than they are at predicting annual mean concentrations, and the process of model verification is extremely challenging*"<sup>4</sup>.

The proposed methodology therefore involves analysis of monitoring data collected in Norwich with reference to daily and seasonal variations, traffic profiles and meteorological data. Analysis of data has been carried out using the Openair<sup>5</sup> package for air quality data analysis within the statistical package "R"<sup>6</sup>.

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<sup>4</sup> Local Air Quality Management Technical Guidance LAQM.TG(09)

<sup>5</sup> Carslaw, D.C. and K. Ropkins, (2012) openair --- an R package for air quality data analysis. Environmental Modelling & Software. Volume 27-28, 52-61.  
David Carslaw and Karl Ropkins (2012). openair: Open-source tools for the analysis of air pollution data. R package version 0.5-18.

<sup>6</sup> R Development Core Team (2011). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. ISBN 3-900051-07-0, URL <http://www.R-project.org/>.

## 2 Baseline Information

### 2.1 Air Quality Monitoring Data

#### 2.1.1 Automatic Monitoring data

Automatic monitoring was carried out at two locations in Norwich during 2011. The locations are shown in Figure 6 and Figure 7. The Norwich Lakenfields (OS Grid References 623637, 306940) site is an urban background location and is part of DEFRA's Automatic Urban and Rural Network (AURN). The Norwich Castle Meadow (OS Grid Reference 623202, 308615) site is a mobile unit that currently monitors roadside concentrations within the Norwich Castle AQMA.

Data for 2011 is available for both the Castle Meadow site (93% NO<sub>2</sub> data capture) and the Lakenfields site (92% NO<sub>2</sub> data capture). Results are shown in Table 2, with provisional 2012 results from the Castle Meadow monitoring station also shown.

**Figure 6 - Castle Meadow Automatic Monitoring Station**

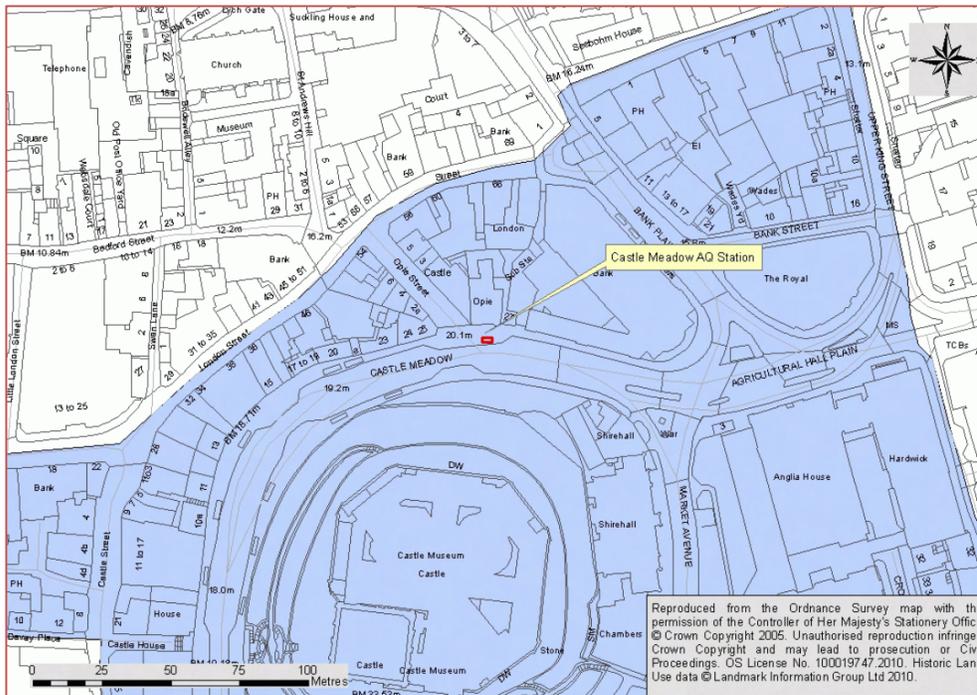


Figure 7 - Lakenfields Automatic Monitoring Station

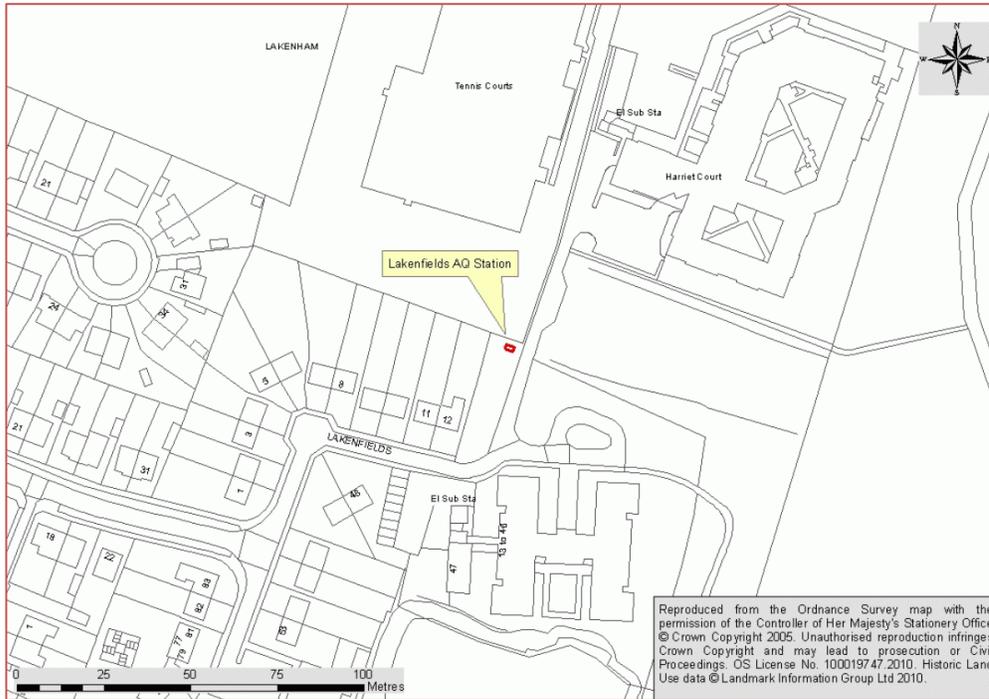




Table 2 - Results of Automatic Monitoring - Comparison with AQS Objectives

Site Name	Pollutant	Within AQMA ?	Objective	Data Capture for Full Calendar Year 2011 (%)	2008	2009	2010	2011	2012*
Castle Meadow (Roadside)	NO <sub>2</sub>	Y	Annual Mean (40 µg/m <sup>3</sup> )	93	45	41	53	52	50
	NO <sub>2</sub>	Y	1-hour mean exceedences (200 µg/m <sup>3</sup> not to be exceeded more than 18 times a year)		0	1	15	34	2
Norwich Lakenfields (Urban Background)	NO <sub>2</sub>	Y	Annual Mean (40 µg/m <sup>3</sup> )	92	-	16	13	13	-
	NO <sub>2</sub>	Y	1-hour mean exceedences (200 µg/m <sup>3</sup> not to be exceeded more than 18 times a year)		-	0	0	0	-

In bold: Exceedences of the AQS objectives  
\* Provisional data up to 03/08/12

Results at the mobile continuous monitor located at the Castle Meadow Site have consistently exceeded the annual mean NO<sub>2</sub> AQS objective over the past four years. The 2011 results remained at a similar level as those recorded in 2010 with only a 1 µg/m<sup>3</sup> fall in concentrations. The measured concentration of 52 µg/m<sup>3</sup> in 2011 confirms the poor air quality in the area and demonstrates the continued need for an AQMA in the area.

The 1-hour mean objective for NO<sub>2</sub> of (200 µg/m<sup>3</sup> not to be exceeded more than 18 times per year) was exceeded for the first time in 2011. The results in 2010 came close to this limit with 15 exceedences of 200 µg/m<sup>3</sup>. The 2011 results show 34 exceedences of the 200µg/m<sup>3</sup> objective (18 are allowed). This is a substantial increase from the 2010 results. It should be noted the road on which the monitoring takes place is restricted to buses only and the monitor is located in a worst case location between two bus stops. The area is likely to be one where people may spend an hour; therefore relevant exposure for this objective does exist. Provisional results for 2012 indicate that the 1-hour mean objective is unlikely to be exceeded in 2012. Only two 1-hour exceedences of 200µg/m<sup>3</sup> were recorded in the first seven months of the year.

### 2.1.2 Nitrogen Dioxide Diffusion Tube Data

Norwich City Council carried out passive monitoring for air quality using NO<sub>2</sub> diffusion tubes at 28 locations across the City. Five of these locations were triplicates. A co-location study was carried out at the Lakenfields (AURN) Continuous Monitor. The NO<sub>2</sub> diffusion tubes used were prepared and analysed by Gradko Ltd using the 50% Triethanolamine (TEA) in Acetone method. Results for these sites between 2006 and 2011 are provided in Table 3. Full details are available in annual air quality reports.

Analysis of UK continuous NO<sub>2</sub> monitoring data has shown that it is unlikely that the 1-hour mean NO<sub>2</sub> objective, of 18 hourly means greater than 200µg/m<sup>3</sup>, would be exceeded where the annual mean objective is below 60 µg/m<sup>3</sup><sup>7</sup>. Monitored annual MEAN NO<sub>2</sub> concentrations for 2011 are below 60 µg/m<sup>3</sup>; therefore using this ratio, the 1-hour mean NO<sub>2</sub> objective would be expected to be met in Norwich. The exceedence of this objective at the Castle Meadow monitoring station, where the annual mean is below 60 µg/m<sup>3</sup> suggests that there may be a short term local source of emissions causing exceedences beyond those that would be expected at a typical roadside monitoring site.

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<sup>7</sup> AEAT (May 2008) Analysis of the relationship between annual mean nitrogen dioxide concentration and exceedences of the 1-hour mean AQS Objective. A report produced for the Department for Environment, Food and Rural Affairs, the Scottish Government, the Welsh Assembly Government and the Department of the Environment in Northern Ireland.

Table 3 - NO<sub>2</sub> passive monitoring results in Norwich

Location	Bias Adjusted Annual Mean Concentrations (µg/m <sup>3</sup> )					
	2006	2007	2008	2009	2010	2011
256 King St	-	<b>45.2</b>	<b>41.2</b>	<b>44.2</b>	<b>41.5</b>	<b>41.9</b>
Queens Rd Travelodge	-	<b>41.9</b>	32.8	37.3	<b>40.3</b>	31.8
25 Surrey St	-	33.5	27.3	29.9	31.1	-
St Stephens (mid)	<b>46</b>	<b>46.4</b>	<b>48.4</b>	<b>52.1</b>	<b>54.5</b>	<b>53.0</b>
Chapelfield/Wessex St	32	35.6	30.5	36.1	-	-
Lakenfields	-	-	-	13.6	15.1	13.1
26 Johnson Place	<b>41</b>	33.7	24.3	31.9	-	-
Chalk Hill Rd	-	-	-	30.9	34.1	31.1
130 Magdalen St	-	<b>40.1</b>	36.7	35.2	39.7	29.0
Reads Flour Mill	-	-	-	23.8	24.9	23.1
Grapes Hill (upper)	25	28.4	23.2	26.7	26.3	24.9
Exchange St	<b>42</b>	<b>42.3</b>	<b>41</b>	<b>40</b>	38.7	32.7
50 St Augustines	<b>50</b>	<b>52.1</b>	<b>50.9</b>	<b>56.2</b>	<b>55</b>	<b>47.5</b>
Tombland	<b>42</b>	<b>47.7</b>	27.8	30.1	36.3	-
Upper King St	32	37.8	32.4	34	26.3	35.2
73 Prince of Wales Rd	-	39.1	31.8	35.4	36.3	-
Cattlemarket Street	<b>42</b>	<b>52.8</b>	<b>43.1</b>	<b>50.3</b>	<b>48.4</b>	<b>45.0</b>
Castle Meadow	<b>46</b>	<b>52.9</b>	<b>48.8</b>	<b>53</b>	<b>58.4</b>	<b>51.1</b>
Castle Meadow 2	<b>46</b>	<b>46.6</b>	<b>45.3</b>	<b>47.1</b>	<b>49.6</b>	<b>52.5</b>
Grapes Hill (lower)	29	30.7	28	27.8	29.5	25.6
32 Key and Castle Yard	-	35.6	31.9	33.7	-	-
29 St Martins Rd	-	25.3	22.7	26.3	-	-
Boundary PH 414 Aylsham Rd	-	-	25	23.8	29.1	-
Kerrisons 353 Aylsham Rd	-	-	35.5	37.4	37.2	-
221 Mile Cross Lane	-	-	33	34.8	36	-
13 Aylsham Rd	-	32.7	26.8	30.9	-	-
158 Waterloo Rd	-	<b>41.1</b>	23.9	25	-	-
62 Magpie Rd	-	34.9	32.6	34.2	32.1	31.6
26 Bull Close Rd	-	39.9	35.6	<b>40.5</b>	37.7	35.0
24 Bargate Court	-	38.4	32.8	37.9	39.3	35.1
124 Barrack St	-	32.1	24.9	27.6	-	-
5 Riverside Rd	<b>47</b>	<b>48.6</b>	<b>46.4</b>	<b>54.4</b>	<b>52.1</b>	<b>49.4</b>
Wellington Lane (lower)	32.4	36.7	32.1	33.6	33.9	26.2
71 Dukes Court	-	31.1	27.6	28.4	28.8	27.9
Carrow Bridge House	-	-	-	-	28.8	24.7
288 King St	-	-	-	-	28.4	-
Zipfel House	-	-	-	-	<b>42.3</b>	<b>42.8</b>
68 Bull Close Rd	-	-	-	-	34.5	29.1
32 St Augustines	-	-	-	-	-	36.2
13 St Augustines	-	-	-	-	-	37.6
65 St Augustines	-	-	-	-	-	29.6
Rotary House King St	-	-	-	-	-	<b>40.2</b>

Exceedences in Bold

## 3 Results and Discussion

1-hour mean NO<sub>2</sub> monitoring data from the automatic monitoring stations in Norwich have been imported in to the Openair package that contains a collection of functions to analyse air pollution data and allows plotting of complex plots of air quality data.

### 3.1 Hourly and Seasonal Variations

Figure 8 shows a plot of 1-hour mean NO<sub>2</sub> concentrations recorded at the Castle Meadow monitoring station between 2006 and August 2012 averaged across hours of the day and season and Figure 9 shows a plot of variation in traffic flow on Castle Meadow on a typical weekday.

The noteworthy aspects of these plots are:

- 1-hour mean NO<sub>2</sub> concentrations are significantly lower in the summer months;
- There is a clear evening peak in 1-hour mean NO<sub>2</sub> concentrations before 6pm; and
- There is no clear hourly peak in traffic flow on Castle Meadow.

As there is an evening peak in recorded NO<sub>2</sub> concentration and no evening peak in traffic volume on Castle Meadow, it is likely that some other aspect of traffic movement is increasing emissions. This could be due to increased idling or queuing as buses wait to join the wider road network, which is likely to be more congested at this time of day. There may also be increased bus idling during boarding as passenger numbers are likely to be higher.



Figure 8 - Daily and Seasonal NO<sub>2</sub> Variation in Norwich

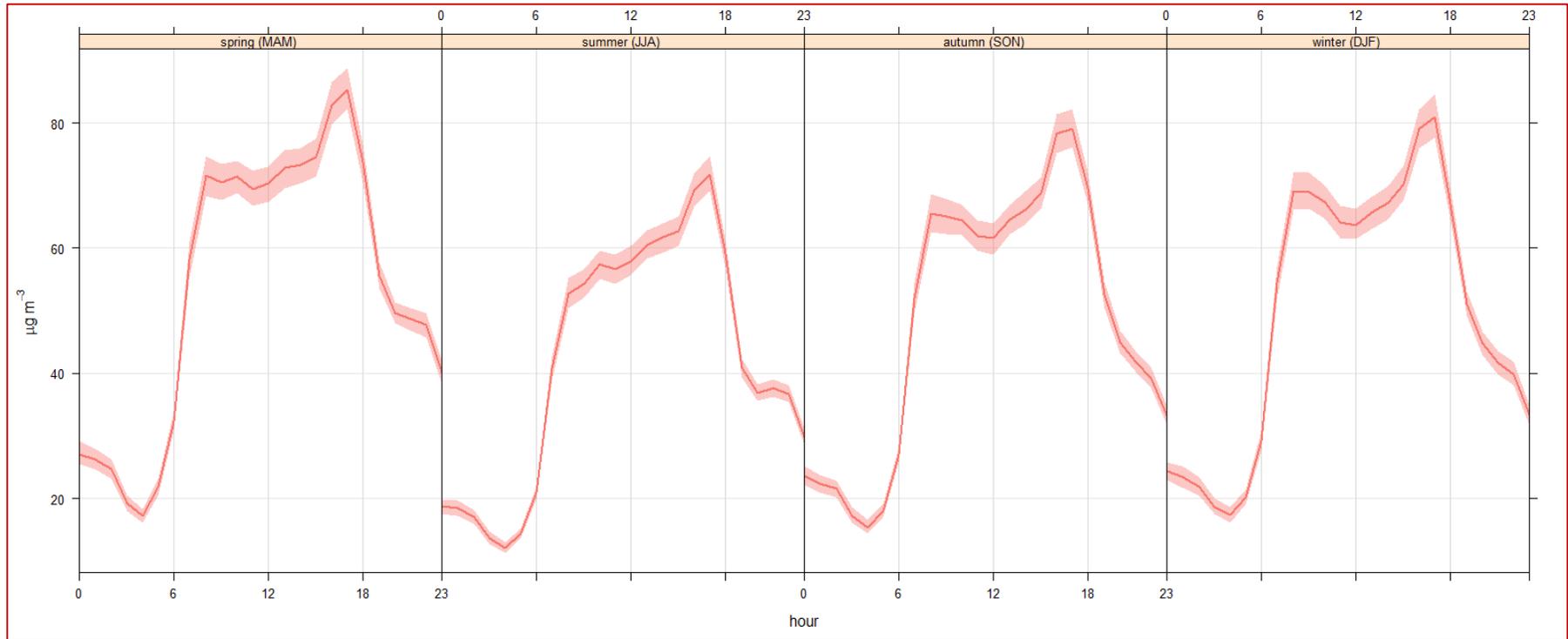
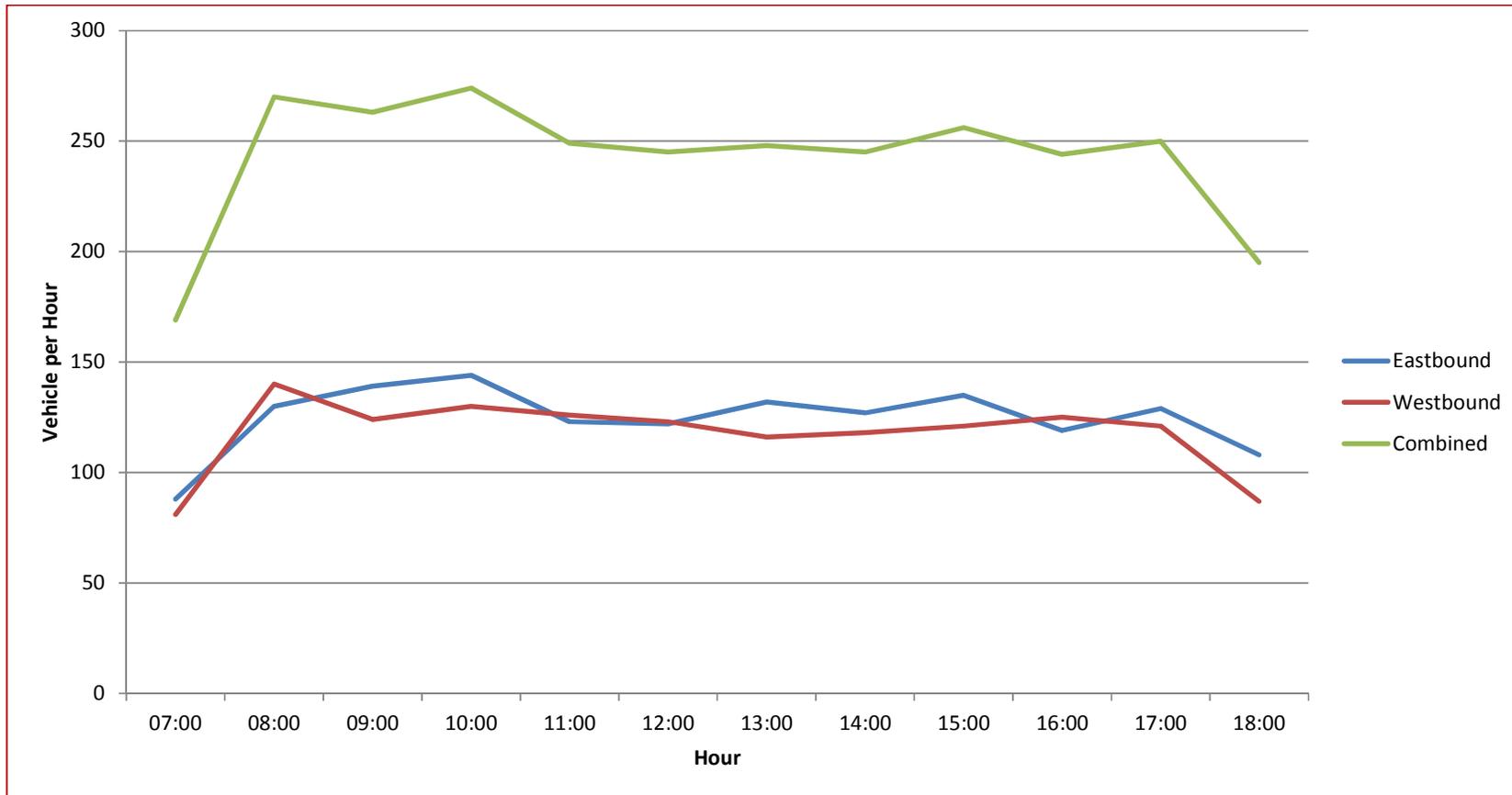




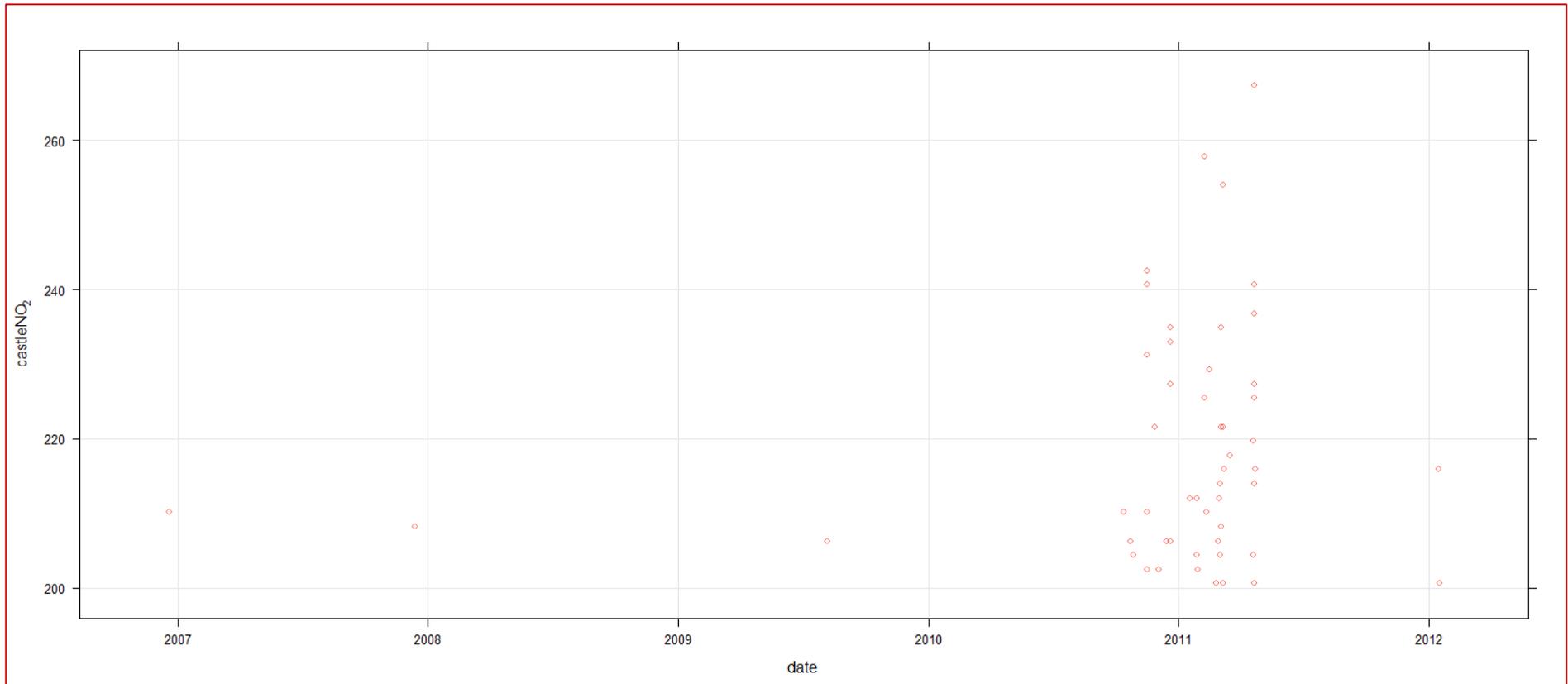
Figure 9 - Daily Traffic Variation on Castle Meadow



### 3.2 Exceedence Timing

Figure 10 shows the timing of all 1-hour mean NO<sub>2</sub> exceedences of 200 µg/m<sup>3</sup> recorded at the Castle Meadow automatic monitoring station since 2006. Over this period there have typically been around one 1-hour mean exceedence per year, until the winter of 2010, when there were numerous exceedences as seen in the 2010 monitoring results, carrying into the early part of 2011. There have only been two exceedences of 200 µg/m<sup>3</sup> since April 2011. All exceedences occurred on weekdays between the hours of 8am and 7pm.

Figure 10 – 1-Hour NO<sub>2</sub> Exceedences of 200 µg/m<sup>3</sup> at Castle Meadow Monitoring Station



## 4 Conclusions and Recommendations

As part of the LAQM regime, a Detailed Assessment based on analysis of monitoring data was carried out for Castle Meadow, Norwich. This was required as more than 18 exceedences of the NO<sub>2</sub> 1-hour mean air quality objective of 200 µg/m<sup>3</sup> were recorded at this monitoring site in 2011.

Analysis of the variation in recorded NO<sub>2</sub> concentrations across the day in comparison to local traffic profiles indicates that whilst there is no evening peak in traffic flow, there is an evening peak in NO<sub>2</sub> concentration. This indicates that traffic flow patterns in this period change to increase NO<sub>x</sub> emissions. This may be a result of increased idling with increased bus occupancy, or increased queuing as buses seek to join the wider road network, which is likely to be congested in this period.

The key finding of the analysis of the monitoring data is that the overwhelming majority of 1-hour mean exceedences of 200µg/m<sup>3</sup> that have occurred over the last six years occurred over the winter of 2010/2011 up to the end of April 2011. This indicates that there may have been a short-term set of circumstances over this period causing exceedences. If these circumstances are not repeated, then, based on previously observed seasonal trends, it is highly unlikely that the 1-hour mean objective will be exceeded at Castle Meadow. Provisional data indicates that the objective will not be exceeded in 2012. It has been indicated that highways improvement work on Castle Meadow during this period may have involved the use of construction plant which may have had combustion emissions, contributing to the exceedences.

This leads to the conclusion that an AQMA for the 1-hour mean NO<sub>2</sub> objective is not required, as the objective was only exceeded as a result of short-term circumstances that are unlikely to be repeated. This will be confirmed in the 2013 Progress Report, when fully ratified 2012 monitoring data is available.

M G Stephenson  
Public protection manager

If you require this document in another language or format,  
eg large print, audio cassette or Braille, please contact:

Public protection  
City Hall  
Norwich  
NR2 1NH  
t: 0344 980 3333  
e: [info@norwich.gov.uk](mailto:info@norwich.gov.uk)

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